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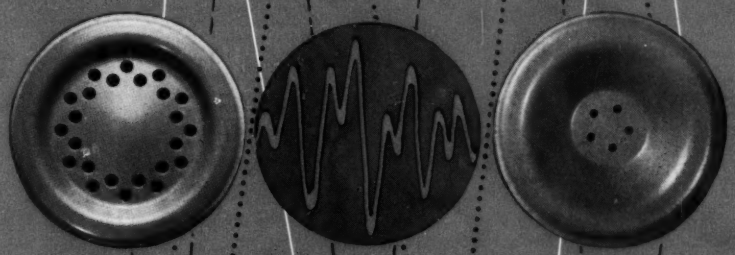

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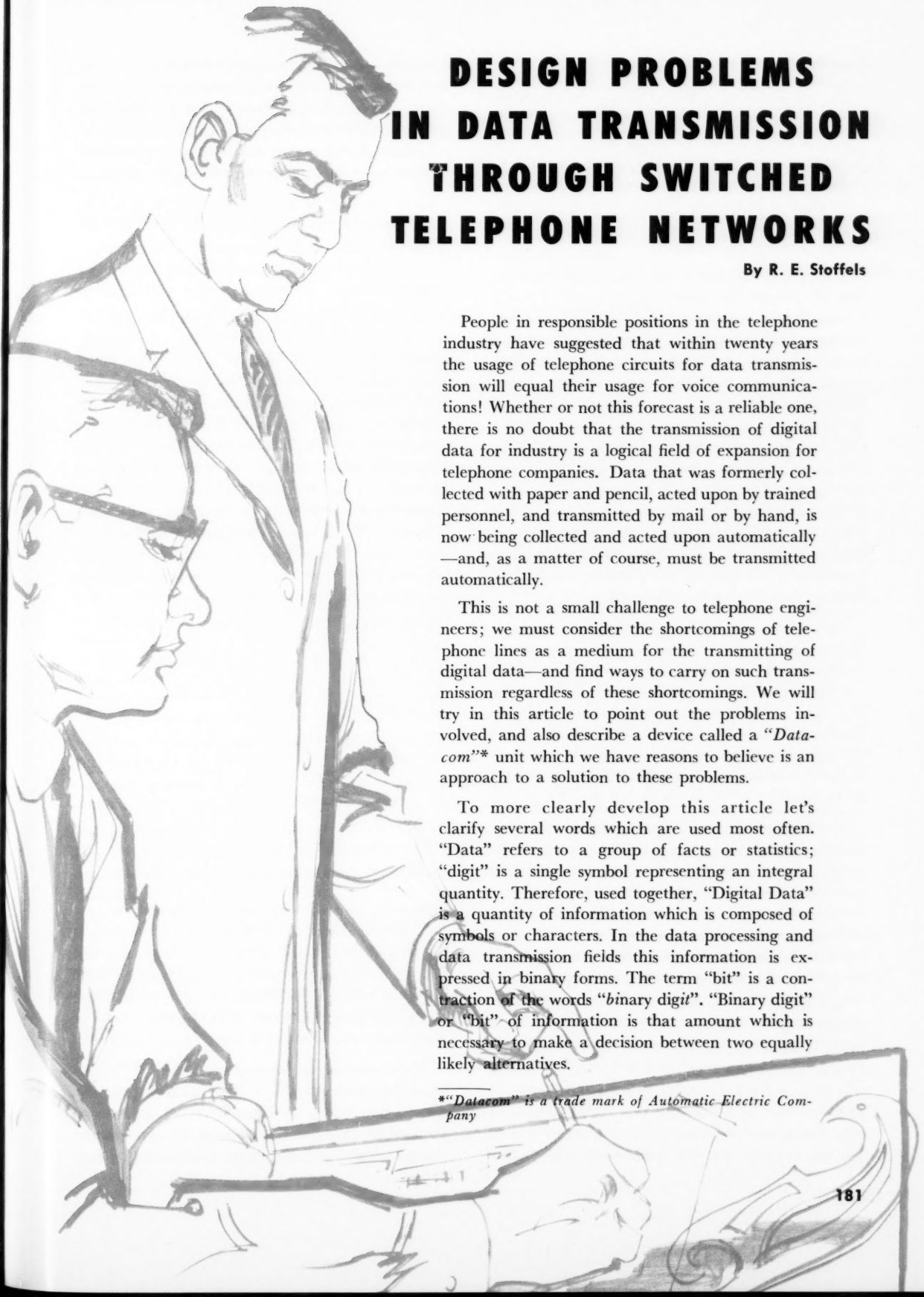

DESIGN PROBLEMS IN DATA TRANSMISSION THROUGH SWITCHED TELEPHONE NETWORKS

By R. E. Stoffels

People in responsible positions in the telephone industry have suggested that within twenty years the usage of telephone circuits for data transmission will equal their usage for voice communications! Whether or not this forecast is a reliable one, there is no doubt that the transmission of digital data for industry is a logical field of expansion for telephone companies. Data that was formerly collected with paper and pencil, acted upon by trained personnel, and transmitted by mail or by hand, is now being collected and acted upon automatically —and, as a matter of course, must be transmitted automatically.

This is not a small challenge to telephone engineers; we must consider the shortcomings of telephone lines as a medium for the transmitting of digital data—and find ways to carry on such transmission regardless of these shortcomings. We will try in this article to point out the problems involved, and also describe a device called a *"Datacom"** unit which we have reasons to believe is an approach to a solution to these problems.

To more clearly develop this article let's clarify several words which are used most often. "Data" refers to a group of facts or statistics; "digit" is a single symbol representing an integral quantity. Therefore, used together, "Digital Data" is a quantity of information which is composed of symbols or characters. In the data processing and data transmission fields this information is expressed in binary forms. The term "bit" is a contraction of the words "*bi*nary digi*t*". "Binary digit" or "bit" of information is that amount which is necessary to make a decision between two equally likely alternatives.

*"*Datacom*" *is a trade mark of Automatic Electric Company*

Transmission

The transmission of digital data over telephone lines is not entirely new to the telephone industry —in fact, the vast teletypewriter networks use, for the most part, existing telephone lines. In order to make digital data transmission possible, a language translation is necessary. This is due to the basic characteristic of a telephone line—or, to be more precise, a telephone channel.

A telephone channel is not capable of transmitting all frequencies from 0 cps up; if it could it would not be economical, since a telephone channel was initially designed to transmit the voice, and to do this, only those frequencies from approximately 250 cps to 3000 cps must be reliably transmitted. Therefore, a telephone channel is essentially a bandpass filter which severely attenuates those frequencies below approximately 250 cps and above 3000 cps (these cutoff frequencies will vary from circuit to circuit). Because of the low-frequency limitation of the telephone channel, all pulses emanating from the teletypewriter machines must be in the form of alternating current of a frequency over 250 cps. Several language translations, commercially employed, will be discussed later.

The operating speed of the popular teletypewriter machine is somewhat less than 80 bits per second. If the stream of transmitted bits varied continuously between "yes" and "no" (or mark and space), then the envelope frequency of this intelligence wave would be 40 cps (Figure 1). If the transmitted bits do not vary from "yes" to "no" at this maximum rate then the envelope frequency of the intelligence wave will be less than 40 cps.

The bandwidth necessary to transmit this intelligence-carring envelope is twice the maximum envelope frequency, or 80 cycles. This does not come anywhere near the width of a telephone channel (which we saw was approximately 3000-250 = 2750 cps), and indeed, commercial systems stack many such teletypewriter channels on one telephone channel by using telegraph carrier equipment.

According to authorities, the maximum bit rate is twice the bandwidth; therefore on a telephone channel whose bandwidth is 2750 cycles we should be able to transmit 5500 bits per second. However, this bit rate has never been commercially attained, and may not be for a long time. The highest bit rate which has been commercially realized is 3000 bits per second; this was achieved by the Collins Kineplex system, but it requires complex terminal equipment, as well as a high quality, private, telephone channel. It appears now that the telephone industry will be very pleased if it can transmit data at a speed of one to two thousand bits per second without using very elaborate equipment.

There are several limitations inherent to a telephone channel which make high bit rates difficult to attain:

Impulse Noise

Virtually all telephone channels pass through one or more central offices and there is a considerable amount of electrical impulse noise within these offices caused by dialing pulses, switches stepping, relays releasing, etc. This noise is inductively coupled to nearby channels, thus presenting this noise, more or less, to every channel entering and leaving the office. Because of the short duration of this noise the ear is rather insensitive to it, so telephone conversations may be carried on with little difficulty. "White" noise (random fluctuation noise whose power is uniformly distributed over the entire frequency spectrum) and constant tones, on the other hand, are easily heard. As a result of this phenomenon, noise-measuring sets are designed to ignore impulse noise, and a telephone channel which is very bad as far as impulse noise is concerned might be considered to be quite satisfactory for telephone transmission.

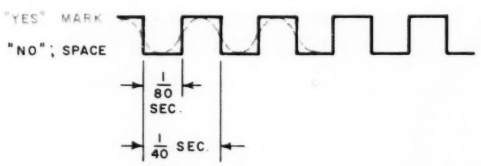

Figure 1. Operation Speed and Intelligence Wave Diagram

Data transmission thus becomes difficult, because it is this impulse noise which is most detrimental to the binary information being transmitted. A single bit of intelligence transmitted at high speed is on the order of one millisecond in length, while bursts of impulse noise can easily be of the same order of magnitude, and often, of a much larger amplitude.

When noise on a telephone channel gets particularly bad a compandor is often used, but effective though this is for a telephone channel, it serves no useful function on a data channel. The compandor tends to "turn off" the channel when actual con-

versation is on the line, and is able to provide a maximum improvement of 23 db in the signal-noise ratio. During conversation the compandor is not in use, and the voice overrides whatever noise is present. It can be seen that such a device is not useful in data transmission.

Frequency Band Shift

A telephone conversation being transmitted between two points often travels over several types of facilities; cable, open wire, various types of carrier, and even microwave may be used at the same time. Thus the frequency of the carrier is shifted up and down the spectrum. In utilizing single-sideband suppressed-carrier systems, it is possible to lose or gain up to 1 cps between sending station and receiving station. This shift, unnoticeable to the ear, is important to data devices. As the transmission speed goes up this shift becomes more and more important, and it must be given serious consideration in the design of a data transmission system.

Delay Distortion

Because the ear is insensitive to differences in phase, minor phase distortion is completely unnoticed in a telephone conversation, and nothing need be done to correct it. Let's explain this distortion. Any signal being transmitted down a length of wire is not only attenuated, but also delayed; and just as the attenuation varies depending upon the frequency of the signal, the time delay also varies. The absolute value of this time delay is of little importance, but the difference in delay between the various frequencies of the band is of the utmost importance in data transmission. This difference in delay is called delay (or phase) distortion.

Because the envelope frequency changes continuously during message transmission, phase distortion will cause inter-bit interference at the receiving station. This is especially true at high bit rates, where sidebands become appreciably large.

Line Correction

It is possible to correct the transmission line so as to make it capable of high-speed transmission, but here the economics of the situation must take over. A private line may be shielded in the central office to protect against impulse noises, extremely stable carrier systems may be chosen to protect against frequency shift, and delay equalizers may be added to correct for phase distortion; but all of these correction procedures cost money. In addition, although this improvement is possible in a leased private line, it is not at all possible in a dailed-up connection; because of these difficulties, the maximum attainable speed of transmission is seriously limited.

Transmission Systems

There are two types of data transmission systems in common use: the synchronous, and the start-stop.

The synchronous system is the simplest in theory, but is the most expensive and the most difficult to maintain. In this system the receiver must sample the incoming intelligence at precisely the same rate as it is placed on the line by the distant transmitter. The sampling rate, as well as the transmission rate, are normally controlled by synchronous motors and hence depend upon identical power sources at both stations to maintain synchronization. The 60-cycle current, although extremely accurate over a 24 hour period, is notoriously inaccurate in any one minute. It may very easily vary by one or two cycles during heavy load periods, and this is a change of more than two percent. Therefore, a transmitter at one station may be experiencing 62 cps current, and a receiver at another station may have 58 cps. It can easily be seen that a transmitter and receiver would rapidly fall out of step. This difficulty may be corrected if two stable oscillators are used, one to control transmission, and the other to control reception. But the expense of such a system is considerable, and even when used it is necessary to occasionally synchronize the receiver to the transmitter.

In the start-stop system the receiver is allowed to run slightly faster than the transmitter; therefore, even under the worst frequency conditions the transmitter cannot get ahead of the receiver. Because of this higher receiver speed it must occasionally be stopped to allow the transmitter to catch up. Usually this stopping is accomplished once per character, hence the name "start-stop". In this system, however, it is necessary for the transmitter to transmit a short "start" pulse containing no intelligence, during which time the receiver will get

up to speed in preparation for receiving the intelligence pulses. Likewise there must be a "stop" pulse, during which time the receiver will come to rest (Figure 2(a). This start-stop system is the most popular in present day systems, but, because it must contain two pulses containing no intelligence, it wastes time.

Now let us consider the four modulation schemes in popular usage for transmitting the intelligence:

Amplitude Modulation

The system first used in the transmission of teletypewriter information was the "on-off". In the system a "yes" or "mark" was represented by a voice frequency tone, and a "no" or "space" was represented by the absence of this tone (Figure 2(b). In the true sense, therefore, this is an AM system, since there is no modulation at all, or the modulation is complete. Usually both sidebands of this carrier frequency are also transmitted. Note, that if the maximum bit rate is 80 bits per second, then the maximum envelope frequency is 40 cps, and the wave which must be transmitted is the carrier frequency *plus* and *minus* the envelope frequency, or Fc$\pm$ 40 cps. Because the carrier is absent a good portion of the time this system is quite susceptible to noise.

Vestigial Sideband On-Off

In this system filters eliminate one sideband and a portion of the carrier. The other sideband and a small amount of the carrier signal are quite adequate for transmission of the data, since all the intelligence is present in each of the sidebands. The small portion of the carrier allowed to remain is amplified in the receiver and mixed with the received sideband prior to detection.

Frequency Modulation

The system which is rapidly replacing the AM is the frequency-shift, or FM system. In this system a "yes" or a "mark" is represented by one frequency and a "no" or "space" is represented by a second frequency (Figure 2(c). The technical considerations of this system are very similar to that of the AM system, except that the FM is less vulnerable to noise. Detection schemes in the receiver may act on the push-pull principle, using either tuned tank circuits or zero crossing devices.

Phase Modulation

The latest modulation system, and the one which appears to have the greatest future, is phase modulation. In this system a continuous carrier wave is transmitted, but its phase is shifted depending upon whether the intelligence bit is a "mark" or a "space" Figure 2(d). This system is probably most immune to delay distortion, but it is extremely susceptible to frequency band shift. As a result it is often necessary to employ a local oscillator for frequency stabilization; this, of course, makes such a device quite expensive.

It has often been stated (and not without considerable justification), that the code transmitting the data should carry its own error-checking code. It is certainly quite true that the transmission medium will be responsible for only a small percentage of errors reaching the distant end. The usual justifying argument relates to the fact that there is no error-checking device on the telephone. Let us consider the following example:

"At the sending end is a man who speaks English with an accent (and in addition he has a tendency to stammer). At the receiving end there is a man who has a high-frequency hearing loss. The man at the sending end wants 47 Woodruff keys. After an elaborate telephone conversation in which understanding seems to be complete, the man at the sending end is surprised to receive a key to the company offices at No. 47 Woodrow Street. The machine domain was working perfectly, but errors in the human domain were large".

Notwithstanding this rather amusing argument, it seems quite certain that eventually the telephone company charged with transmitting the digital data will be required to either transmit each character perfectly or give an indication when a transmission error has occurred. Considerable work will have to be done on this phase of the subject.

Terminal Devices

We have, up to now, considered the devices which will take intelligence and transmit it over a telephone channel, and receive this intelligence at the distant station. We have discussed the speed capabilities of the telephone channel, the problems encountered in transmitting intelligence, and the modulation systems which are commonly used. Now let us briefly investigate the type of machine which will be used to generate this intelligence at one end

and present, at the other end, this intelligence in a usable manner.

There are in use today thousands of teletypewriter machines, which normally use a start-stop code, with the stop pulse either exactly as long as an intelligence pulse, or more commonly, 1.42 times as long (Figure 2). These machines usually use five-channel paper tape; that is, each character consists of five bits. In the binary system this permits the use of 32 characters ($2^5 = 32$). If more

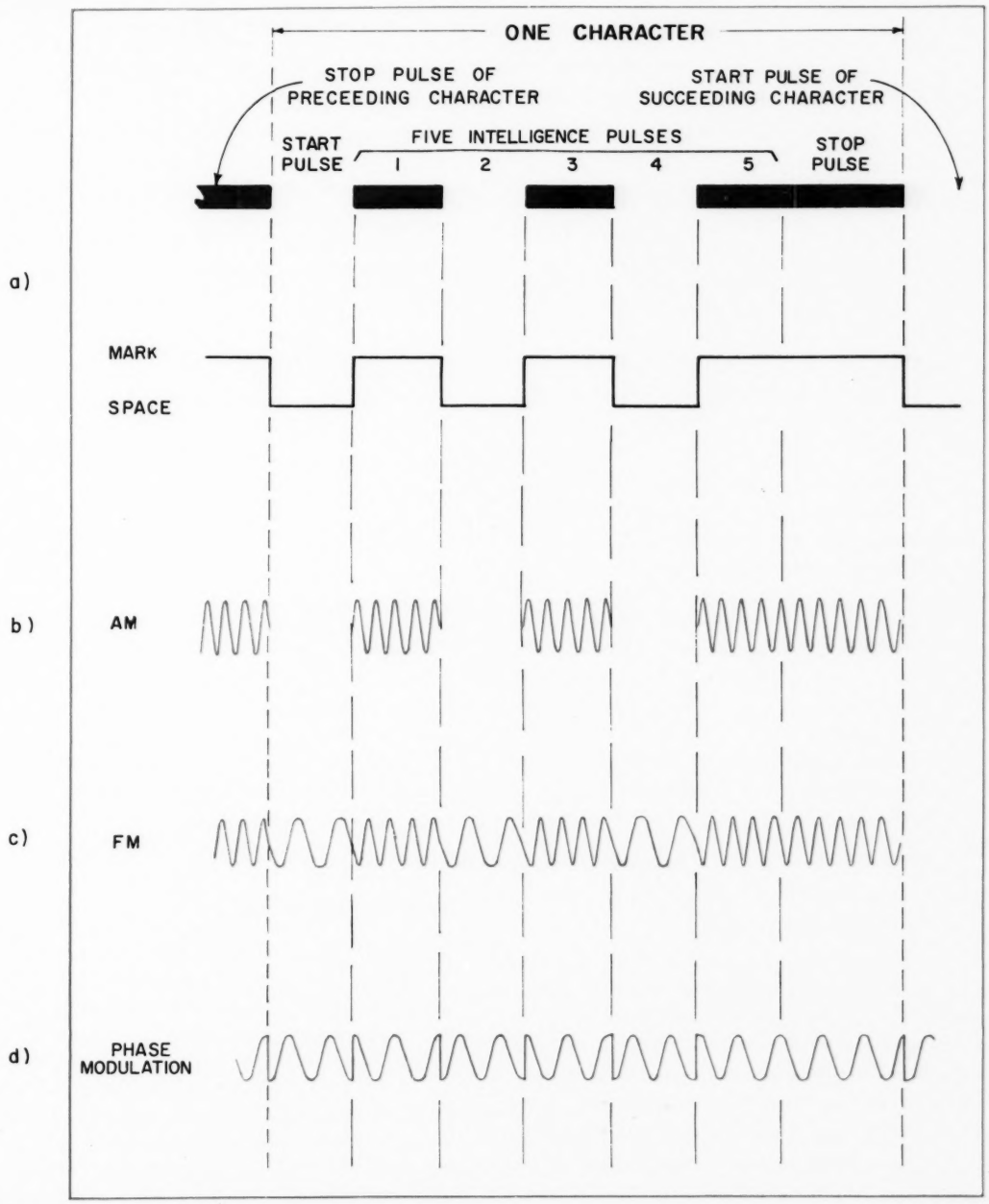

Figure 2. Transmission System Showing Start and Stop Pulse Modulation

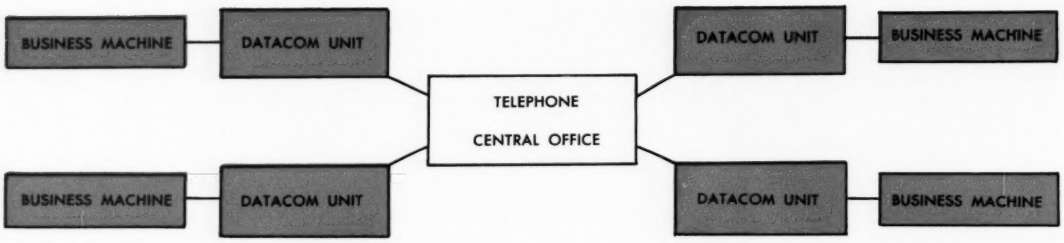

Figure 3. Block Diagram Showing "Datacom" Units in Relation to Central Office and Business Machines

possible combinations are required a sixth channel is added. If, in addition, a parity check is required of each character then an additional channel is added. Very often, in fact, eight channels are used in transmitting data.

Magnetic tape is coming into wide usage today, and the type of tape used varies considerably, both as to the number of intelligence channels, and the bit spacing. Punched cards are used by several companies, and both the physical dimensions and the number of holes varies considerably from one to the other.

Machines capable of transmitting data from one place to another are now made by Teletype Corp., Smith-Corona, Inc., Remington Rand Co., International Business Machine Corp., National Cash Register Co., and many others. These companies are mentioned to point out that in the data field, the codes used for transmitting data, and the means used for recording data, vary enormously. It appears that any device used by the telephone company to transmit data must not try to replace these business machines, but rather must accept data from them at one end, and present data to them at the other end. It must perform a translation from the language of the business machine, to a language capable of being transmitted over telephone channels and back again to the language of the business machine (Figure 3).

Such a device must be quite flexible; that is, it must be capable of working with as many of these terminal machines as possible. And at all times the questions of economics must be kept in mind; the problem of transmitting the largest number of "bits" for the smallest number of dollars.

It now only remains to determine a direction; to design a device which will be most usable by the data industry today. Such a device should not be of the most sophisticated nature, since this would make it prohibitively expensive. On the other hand it should not be too simple and elementary, since such a device would not properly perform the required functions. We believe that a device designed in our Laboratories, called the *"Datacom"* digital data communication set, is a big step forward in satisfactorily meeting these requirements.

The "Datacom" unit is a transmission device which accepts information from a business machine and does not try to replace the machine.

In the "Datacom" unit an FM modulation system is used; equipment utilizing FM modulation is commercially available, and has been perfected to a high degree. In addition, by using such a system it is possible to *hear* the transition from mark to space, an advantage which would not be realized with phase modulation.

Telephone lines are used on a demand basis; thus leased lines associated with the equipment on a permanent basis are unnecessary. Data is accepted from the associated business machine in a sequential form; therefore, the number of intelligence channels used by that business machine is immaterial. The system is non-synchronous; the expense of local controlled oscillators is eliminated.

Datacom Unit—Figure 4

The "Datacom" unit consists of tone equipment and equipment required to convert the d.c. language of the business machine into a "tone" language compatible with the voice-frequency telephone lines; control equipment required for the necessary dialing, automatic answering, switching from voice communication, and resetting of equipment; and loop equipment, which serves to connect the particular business machine to the "Datacom" unit, and is necessary because of the different characteristics of various business machines.

Tone Equipment—Figure 5

The tone equipment uses standard Lenkurt Type 23A Telegraph Carrier equipment and is entirely transistorized, operating on a frequency-modulated basis. The carrier frequency used is 1955 cps, and the mark and space frequencies are formed by shifting the carrier frequency between values which are 35 cycles above and below the nominal mid-band frequency. Consequently the mid-band frequency of 1955 cps never actually appears. Both transmitting and receiving-line power levels may range from +6 dbm to —40 dbm. The equipment is designed for a line impedance of 600 ohms.

Figure 4. "Datacom" Unit

Transmitting Equipment

In the transmitting equipment, a diode modulator is used to insert or remove a shift capacitor from the oscillator tank circuit, thus minimizing the effect of the line to the business machine. The oscillator can best be described as a regenerative flip-flop whose oscillations are limited by clipping in both transistors. This stage feeds a buffer amplifier; the output is fed through a two-transistor amplifier, and an output transformer feeds the transmission line.

Receiving Equipment

In the receiving equipment, the signal is fed through a pad, if required, then through a bandpass filter, and a single stage of amplification. It is then severely clipped, and fed through a transformer to a push-pull stage. The output of this stage feeds a discriminator of the double tuned series-resonant type. One mesh is tuned to a frequency close to the mark frequency, and the other mesh is tuned to a frequency close to the space frequency. The output of each mesh is bridge-rectified, and the two currents are combined differentially. The resultant signal then feeds two

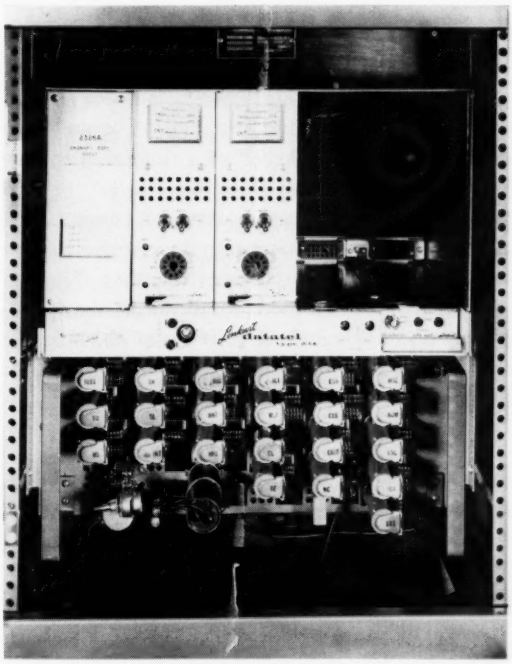

Figure 5. Inside View of "Datacom" Unit Showing Transmitting and Receiving Equipment

power transistors connected as d-c amplifiers, and the final output drives a polar relay connected in a polarential configuration.

Just past the limiting stage of the receiver, a portion of the signal is tapped off and fed through two stages of amplification. The second stage is connected as a d-c amplifier, and the output feeds a relay which is released if a tone is present, and operated if there is no signal. Thus we have a very effective "no-tone" detector.

Control Equipment

The function of the control equipment begins when a call is initiated, and ends when the line is released. It includes the initiation of a call from a standard telephone dial, automatic answering of the distant station in response to ringing current, and control of the tone equipment. The equipment consists of a control panel from which all operations are performed, control relays, transistor circuitry used for timing purposes, and a telephone with means for automatically cutting the handset transmitter in and out of the circuit at the proper time. Thus, it is possible at all times to monitor the voice-frequency signals being transmitted and received, and in certain instances, to carry on voice communication.

Because this system provides unattended service, certain additional equipment had to be added to replace the spoken "hello" of a normal telephone conversation with an electronic "hello" or "go ahead". This additional equipment consists of a unit of FM tone equipment, thus providing two additional tones for supervisory functions. The second of these tones is used to indicate an alarm condition, and will sound a buzzer to call the operator at the distant station. Voice communication can then be carried on.

Loop Equipment

Since all business machines do not put out the same kind of signal, there must be some means for permitting the tone equipment to accept the specific signal being used. Very often a neutral signal is used; that is, current is present for the mark, and absent for the space. This current varies from 20 ma to 60 ma. Occasionally a polar signal is used; current is sent in one direction to indicate a mark and in the other direction to indicate a space. Again the current can vary between several values. A strapping block is provided in the loop equipment to make several of these options possible.

Operation

Let us trace the transmission of a message from one station to another. To make this situation a little more complete we will assume that the called station also has a message for the calling station.

For the purpose of discussion we will also assume that the business machine used is a teletypewriter machine which contains a page printer to receive data, and a tape transmitter for transmission purposes. The tape transmitter is equipped with a "tape-out" pin, which shows when the machine is out of tape—that is, a message has ended.

The operator at the calling station momentarily depresses the "Start" button, thus applying power to the electronic equipment and starting the motor of the associated teletypewriter machine, and listens for dial-tone on the handset. Upon hearing the dial-tone he dials the number of the distant station. After the central office has selected this distant station, ringing current is sent out and, instead of operating a telephone ringer, it operates a relay receptive to this ringing current. The operation of this relay applies power to the tone equipment and turns on the motor of the teletypewriter machine.

When the called "Datacom" unit is ready for operation it sends out a "go ahead" tone. The "Datacom" unit at the calling station receives this tone and automatically starts the teletypewriter tape transmitter. The tape passing through the transmitter, with the aid of the loop equipment, modulates the FM tone equipment, thus transmitting data to the telephone channel. When the distant station receives this signal it reconverts it into d.c. signals compatible with the teletypewriter machine; this causes the data to be typed as page copy. Simultaneously, the calling station also reads the signals from the line and causes a monitor copy to be printed by its page printer.

(Notice that the only function performed by the operator was the initial dialing-up of the telephone connection. It is interesting to speculate on the possibility of making the calling station as well as the called station unattended; the simple addition of an automatic dialing device, in conjunction with a clock, is all that would be required.)

After transmission of the message, the tape-out pin rises on the tape transmitter. This releases the transmitter clutch magnet and initiates the transmission of a "go ahead" signal to the called station. (The circuitry is so arranged that the "Datacom" unit initiating the "go ahead" signal cannot receive it.) The "Datacom" unit at the called station receives this signal and starts its teletypewriter transmitter. The message being sent from the called

station is received at the calling station (and as before, at the called station for a monitor record).

When transmission of the message is completed, another "go ahead" signal is initiated. Under normal circumstances the calling station will not have another message; however, if it does it will transmit it, just as before. If it does not have a message, its tape-out pin will be in the raised position and it will transmit the "go ahead" signal to the called station. Since the called station has no message, its tape-out pin will be up; therefore, it will again send the "go ahead" signal to the calling station. This back-and-forth sending of the "go ahead" signal will continue for several seconds. At the end of this time, signal-detecting equipment in each "Datacom" unit will "time out", and both units will release themselves from the line.

As previously mentioned an operator at either station can, at any time, initiate an alarm condition by operating the "Alarm" button on the "Datacom" unit. This causes tone to be transmitted to the line, which is received by the equipment at both stations. This "alarm" signal halts transmission, prevents time-out from the signal detecting equipment, lights an alarm lamp, sounds a buzzer, and connects the transmitters of the telephones. Operators at both stations can now converse in a normal manner. This alarm condition is cleared by an operator at either station, by operating the "Go Ahead" button to allow further data transmission. Notice that action by operators at both stations is not required; the operator at one station can cause an alarm in order to attempt a conversation and if the other station is unattended this same operator can release the alarm. Should the alarm persist for one minute without being answered, the particular unresponding "Datacom" unit releases itself from the line.

Another operating feature of the "Datacom" unit is called "delayed alarm". At times it is advantageous to discuss a message with the distant operator before transmitting it. This is accomplished by operating the "Delayed Alarm" key. In this case the receipt of the "go ahead" signal will, instead of starting the transmitter, cause an "alarm" signal to be sent out.

It was recognized that different users would have many different communication requirements, and therefore the "Datacom" unit was designed to provide maximum flexibility of operation. Not only is it possible to add certain features, (such as Distant-Station Identification), but it is also possible to eliminate features (e.g., to provide for keyboard transmission only). Several of these possible modes of operation are as follows:

Keyboard Transmission

It is quite possible that in certain applications transmission to the line directly from a teletypewriter keyboard would be desired. This has the advantage that the tape perforators and tape transmitter are not needed; however, it is wasteful of line time, since no operator can type as fast as a tape transmitter can transmit. Also it is not possible to proof-read the message before transmission. At any rate, the "Datacom" unit accommodates keyboard transmission with no difficulty.

Operation in a Manual Telephone System

This equipment can be operated with a manual telephone exchange. In such a case the attendant initiating the call operates the "Subscriber Dial Operator" key to the "Operator" position, and then pushes the "Start" button. This causes the transmitter of the telephone to be connected to the line; the attendant can now pass instructions to the operator at the central office. When the distant station answers, the handset is replaced, the "Go Ahead" button is pressed, and transmission begins automatically.

Security System

In certain applications of the fully automatic system, positive identification of the distant station would be required before starting transmission. Such a security system has been added. In this case transmission of a message is contingent upon the receipt of a predetermined code from the distant station. (In a telephone system the recognition of the called party's voice usually provides the only "security measure".)

Automatic Dialing

The delivery or collection of information during night-time hours would permit the user to take advantage of low rates, but the necessity of having even the calling operator on duty at this time might make such operation undesirable. The addition of a "Dialaphone" dialer, or other automatic dialing device, in conjunction with a timing device, would make such night-time operation completely automatic.

SPECIAL

Figure 1. Type 80 Telephone with New Message-Waiting Flashing Lamp.

Modern hotels and motels try to offer "all the comforts of home"—and this should include the very latest in telephone service. To meet the needs of their guests, however, these establishments need several types of service that are not provided by ordinary telephone equipment.

This article will describe a number of service facilities that have been developed to meet these special needs—making it possible now for the telephone company to provide a complete and coordinated communication service to their hotel and motel subscribers.

Room-to-Room Guest Dialing

Here is a most desirable telephone service, from a guest's point of view. By dialing a predetermined number the guest can have convenient, direct, and private room-to-room service, without the necessity of operator assistance. To protect the guest from being disturbed after night retirement, a blocking circuit will provide a busy tone to the calling party —or it will route the call to the P-A-B-X operator, who can dispose of the call.

The system can also provide various special services—accessible by dialing "one digit" numbers.

For example:

"0"—connect to the P-A-B-X operator for making reservations in a distant city.

"9"—connect to a local city telephone exchange

"8"—connect to room service for food or beverage

"7"—connect to maid and/or valet service

"6"—connect to garage or service station for delivery or pickup of automobile

"5"—connect to paging service

"4"—connect to the hotel recording machine: a recorded message would inform the guest of local facilities available — swimming pool, shuffleboard, local attractions, etc.

These are only a few of the services that can be provided by this one-digit dialing system: other services could be provided as required for the convenience of the guests.

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P-A-B-X SERVICES FOR HOTELS AND MOTELS

By D. J. Zukausky

Local Trunk Calls

Facilities are also available so that a guest can dial a local city (2L-5N) exchange terminal directly from his room. He would simply dial a one-digit number (9—central office dial tone would be heard) and then the local exchange terminal number. Circuits can be provided so that charges on such calls can be readily tallied; each time a guest completes a local city call a meter assigned to his individual line will operate. The circuitry on this type of call is not complex; the P-A-B-X central office trunk circuit is arranged to accept the standard reverse-battery (on answer) signal from the central office switching equipment, and utilizes the signal to operate the meter. If this trunk circuit is arranged to operate on a two-way basis, calls from the city exchange will terminate on the attendant's cabinet in the hotel or motel.

The meters used for registering completed outgoing local city exchange calls can be mounted on strips suitable for relay rack mounting in the switchroom or in another convenient location. If more desirable, a meter cabinet (400 meters maximum) can be supplied. Meter cabinet occupies slightly more than two cubic feet of space, and is suitable for table or desk mounting. Cabinets are constructed of wood and various finishes are available.

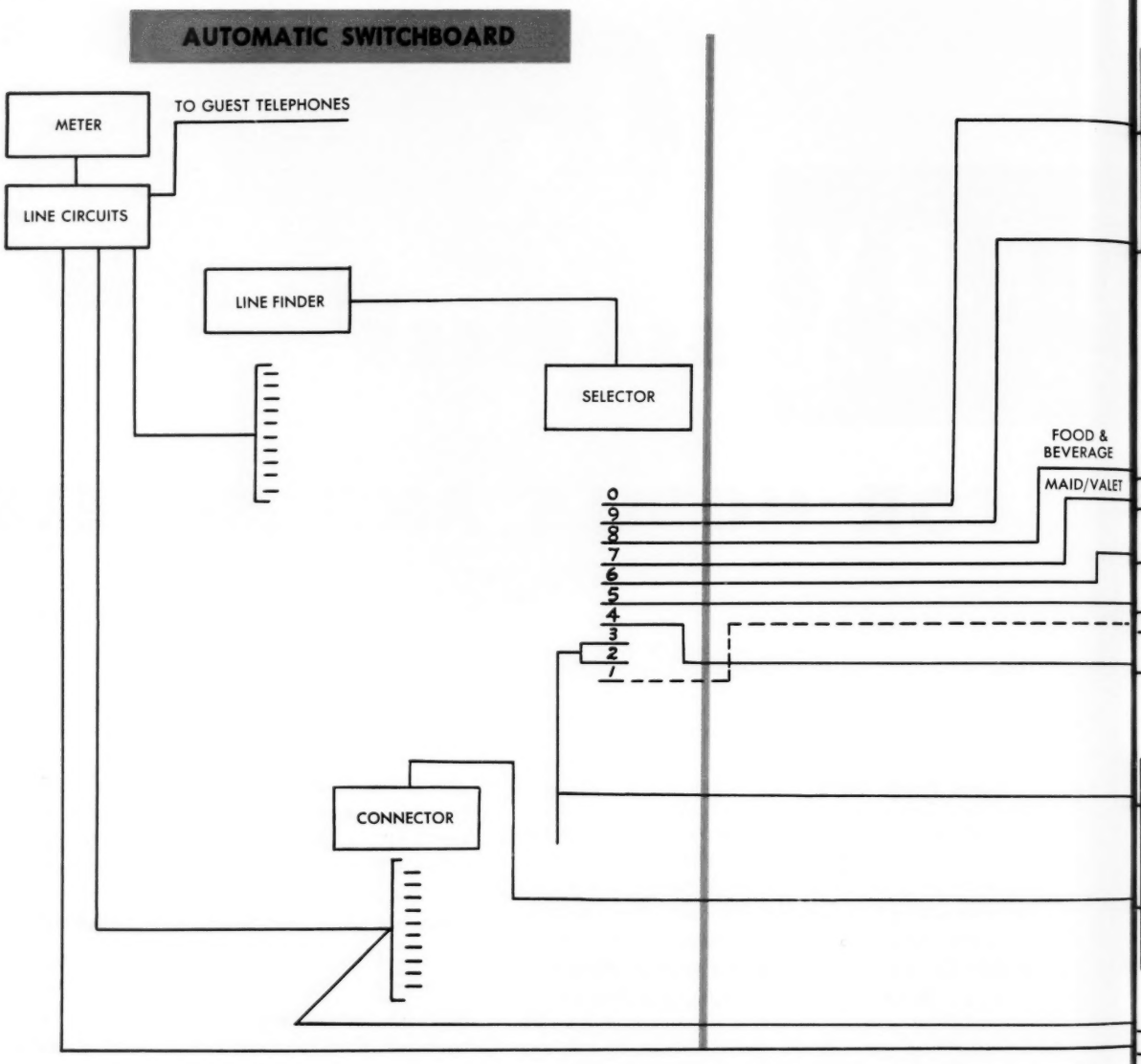
Blocking Long and Short-Haul Toll Calls

Since a guest has direct access to the local city exchange telephone equipment, some means of blocking toll calls must be employed. Blocking of long and short-haul toll calls is deemed desirable, as the circuitry involved for the timing and computation of various toll rates is complex and would entail a considerable expense for equipment.

Toll restrictors, permitting a guest to dial a local city terminal, but not a toll call, solve this problem. If a toll number is dialed the calling party is automatically routed to the P-A-B-X attendant for handling as described below.

Toll Calls

The P-A-B-X attendant has access to the same central office trunk circuit as the guest; however, the attendant's access by-passes the toll restrictor.



If a guest desires to make a toll call, he dials "0" and is connected to the P-A-B-X attendant, who then completes the call via the toll operator. When the toll call has been completed the toll operator can call the P-A-B-X attendant and provide her with time and charges involved on the call.

Since the P-A-B-X attendant is not restricted, she may extend a guest's call through to a short-haul toll number and make a hand-written record of the time and charges involved.

Message-Waiting Service

All calls to the hotel-motel are answered by the P-A-B-X attendant, who can patch each call through to the guest. If the call is important and the guest cannot be reached, the P-A-B-X operator may be called upon to take the message. In the past this meant that the attendant would have to periodically ring the guest's phone until he answered. In a large hotel-motel with many messages waiting to be delivered, this one service could consume all of the attendant's time.

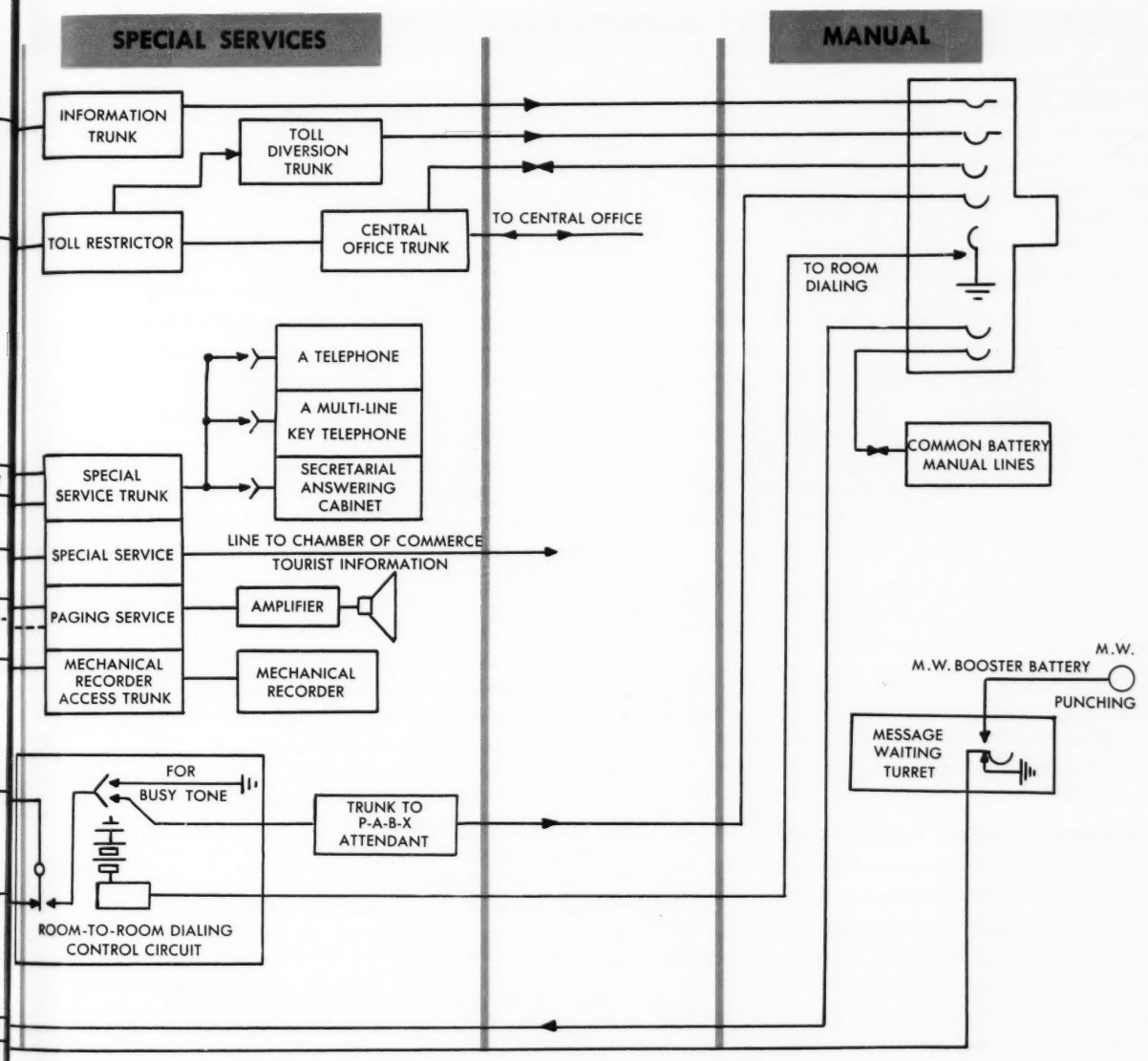


Figure 2. Schematic Diagram showing Special Hotel and Motel P-A-B-X Services

Message-Waiting Indication

For guest's rooms a Type 80 dial telephone arranged with a "message waiting" indicating lamp can be used (Figure 1). Such phones are available in ten colors and black. The indicating lamp is located in the telephone housing, above and to the right of the dial letter "A"; it flashes intermittently, if a message is waiting for the guest. The lamp is controlled by the P-A-B-X attendant, who simply flips a key associated with the guest's line.

The "message waiting" indicating lamp does not affect normal telephone service. The guest may ignore the flashing lamp and make an outgoing call in the normal manner. Or he may answer an incoming call; the lamp will stop flashing when the handset is removed, and will start flashing again when the handset is replaced. To stop the flashing of the lamp, the guest must call the attendant—who will give him the waiting message and then restore the "message waiting" key.

In most small establishments strips of locking push- or turn-keys (one key per line) can be mounted in the P-A-B-X switchboard, in line with the station multiple jacks. If the attendant has a message for a guest she need only make a record of it, and then operate the key associated with the guest's line to start the guest's "message waiting" lamp flashing.

Control of Message-Waiting Indicating Lamp

In a large establishment it may be advisable to free the P-A-B-X attendant from handling message-waiting calls; in this case a small turret, holding the required locking-type keys can be supplied. When the P-A-B-X attendant receives an outside call, and the caller wishes to leave a message for a guest, the call can be extended to the turret, where the special attendant will take the message and activate the "message waiting" lamp.

When such a special "message-waiting" turret is used, the guest can be instructed to dial a one-digit number which connects him to the turret.

The attendant at the turret can be supplied with a multi-line phone or a secretarial answering cabinet so that she can have hold facilities (if required) on incoming calls from guests.

Automatic Equipment Considerations

On New Installations

A two-wire circuit to each guest's telephone is all that is required. Standard, combined line and cut-off, separate line and cut-off or self-aligning plunger lineswitches are used, with the necessary wiring to provide this service, installed at the factory. The only additional equipment required is: one locking-type key per line, a small battery eliminator (50 volts d.c.), and a 3-relay interrupter circuit (common equipment).

A five-relay selector, with 400-point banks, provides the link for one-digit special services. A 4th wire (EC) is required for the meter lead when guests are permitted to dial local city numbers. A diode and normal post springs are included in the selector to provide restricted service.

If room-to-room dialing is desired, standard P-A-B-X connectors are used. Otherwise, no connectors are required; service is provided for by the attendant, on a manual basis.

The one-digit special service trunk circuit in most cases will be a standard automatic-to-manual trunk circuit. This trunk will be accessed via a selector level and will automatically ring-out to the distant end of the trunk.

On Existing Installations

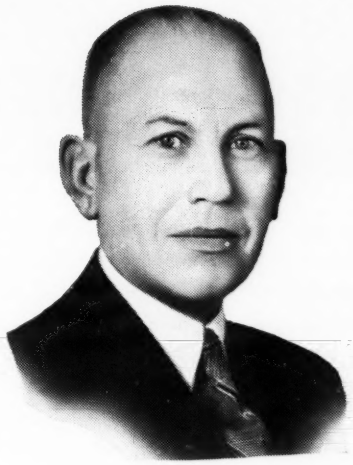
Provision for one-digit special service in existing step-by-step installations is feasible; however, each installation may require engineering consideration to determine the extent of modifications required.

"Message-waiting" indication can also be provided; however, on combined line and cut-off, and separate line and cut-off relay line circuits, a simple wiring change will be required which can readily be accomplished in the field. All that need be done is to remove the ground (usually one grounding lead common to 20 line circuits per plate) that is connected to the positive normal (+N) of each line circuit. Then, at each line circuit connect a lead from the positive normal to a locking key having a break-make combination. The key in the normal position will supply ground to each particular line circuit; when operated it will supply ground plus interrupted booster battery (+) to flash the message-indicating lamp. On existing self-aligning plunger lineswitch boards a similar wiring change must be made. In addition, shelf jack wiring changes are necessary so that 48-volt negative (—) and "message waiting" booster battery (+) are not on adjacent shelf jacks.

Existing selector and connector system P-A-B-X's with existing P-A-B-X central office trunk circuits cannot provide for registering of completed calls to the local city exchange, as the switches will not contain the 4th wire (EC) metering lead, and the existing central office trunk circuits are not likely to be arranged to detect reverse-battery answer supervision from the central office equipment. Converting existing switches is, of course, always a possibility; however, in this case also each circuit must be evaluated individually.

In most cases the existing P-A-B-X attendant cabinet may be used. Each installation must be checked to verify that the existing equipment will function with any new proposed circuits that will provide the desired special services.

Industry Mourns Two Pioneer Telephone Engineers



JOHN E. OSTLINE, an international figure in the telephone industry since 1905, passed away on July 31 at the age of 73.

Mr. Ostline, who retired from General Telephone Laboratories in January, 1958, came to this country from Sweden in 1905 and started his telephone career as a combination lineman, installer and maintenance man for an Independent company in Minnesota.

In 1922, he joined Automatic Electric Company, following a position as assistant chief traffic engineer of Tri-State Telephone Company, St. Paul, Minnesota.

In 1923, the company sent him to London, England, where during the next six years he played a vital role in converting the world's largest city to dial. Also during 1923, Mr. Ostline began work on the foremost achievement of his career—the development of automatic toll ticketing equipment. The invention, finished two years later, was patented in 1928. This and following contributions led to the commercial system known today as SATT.

In 1947, Mr. Ostline received Automatic Electric's highest honor, the Talbot G. Martin award, presented for outstanding achievement in the art of communications.

He was a Fellow of the American Institute of Electrical Engineers, a "Chartered E. E." in Great Britain, and a member of the Institution of Electrical Engineers (England).

DR. ARTHUR BESSEY SMITH, research engineer, inventor and long-time pioneer in communications, died recently at the age of 84.

Dr. Smith received a B.S. in E.E. in 1901 from the University of Nebraska, and worked for telephone companies in Nebraska, Iowa, and New York. During 1905-09 he taught telephone engineering at Purdue University, from which he received his E.E. in 1907.

Joining Automatic Electric in 1909 as assistant to the sales manager, Dr. Smith was soon transferred to the research department and devoted his professional career to research and development. In 1912, he established the Automatic Electric Training School. He was granted thirty-one U.S. patents, and was the inventor of the booster telephone circuit. On the basis of his investigation of the phenomena underlying the slow-acting relay, he received his Ph.D. from Northwestern University in 1926. He was the author of many articles and technical papers, and was co-author with W. Lee Campbell of the book *Automatic Telephony*.

From 1934 until his retirement in 1955, Dr. Smith was a vice president of Automatic Electric Laboratories, Inc. He received the Talbot G. Martin Award in 1943, and the honorary degree of Doctor of Engineering from the University of Nebraska in 1950.

THREE NEW SPECIAL-SERVICE TELEPHONES

Whenever a business organization expands beyond the one- or two-telephone stage, it usually feels the need for some means of holding, switching, and otherwise handling the calls on its several lines. Laboratories has been devoting considerable attention to this problem, and on the following pages we present three different solutions—three telephones from which a selection may be made to meet almost any combination of these requirements.

THE TYPE 85 TELEPHONE Permits Two-Line Pickup and Extension Exclusion

By C. A. Hulik

The Type 85 Telephone has keys to provide two-line pickup, and/or other services. It is made in three models: 85A, with combination "push and turn" key; 85B, with exclusion and switching keys in the handset cradle; 85C, with the features of both A and B. These services are provided without separate key boxes, relays or additional telephone instruments.

The Type 85 Telephone

- —Permits disconnection of an extension ringer
- —Permits switching an extension ringer to an outside line
- —Provides a buzzer signal for business call
- —Permits exclusion of a family telephone (and/or ringer) from business calls

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—Gives access to two subscriber lines from one telephone

—Provides means for signaling a secretary

Most, if not all, of these services could be provided through the use of switching keys, relays, or extra telephones, but with Type 85 Telephones no such auxiliary equipment is required.

Type 85A

This telephone features a "push and turn" key for two-line pick-up and signaling, but with no provision for holding connections. By turning the key the subscriber may answer or originate a call on either of the two lines. This feature is non-restoring —that is, it remains in its last operated position upon completion of a call. With the turn key in either position, the "push" feature can be used to operate a signal, without interference to existing conversation.

The Type 85A is equipped with one ringer, which is supplied wired across Line 1, as shown in Figure 1. However, by merely moving two spade connections, the ringer can be wired to Line 2. Should a second ringer be required for Line 2, any standard ringer box can be installed. The telephone comes equipped with a six-conductor cord.

An arrangement for a two-line secretarial answering service, using this telephone, is illustrated in Figure 2. The secretary may answer either of the two lines, and by means of a buzzer code, direct the call to the proper person. The lines may, of course, be either central or private branch, or one of each. As previously mentioned, no provision is made for line holding.

Some wires in the Type 85A are spade-ended, so it can easily be converted, by operating companies, to the following optional services:

Single-Line Ringer Cut-Off

When Type 85A is used as an extension phone for a bedroom or other quiet location, the ringer may be cut off by turning the key, leaving the extension phone still connected to the line.

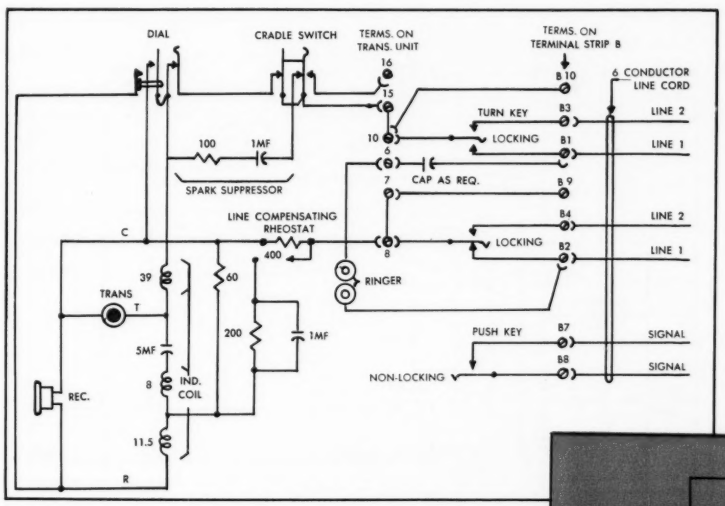

Figure 1. Schematic Wiring Diagram of Type 85A Telephone.

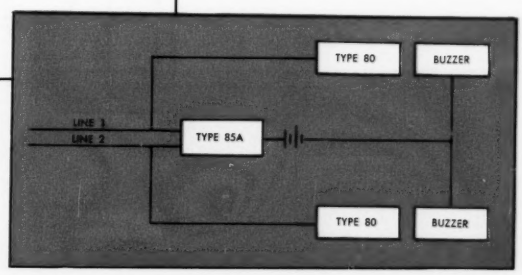

Figure 2. Two-line Secretarial Answering Service with Buzzer Signaling

Single-Line Extension Switching with Ringer Transfer

Turning the key on the "parent" telephone connects the extension telephone and its ringer to the line, and disconnects the ringer on the "parent" telephone, but leaves the telephone connected to the line. Restoring the key connects the "parent" ringer and cuts off the extension telephone and ringer from the line.

External Signal Control

Turning the key connects an external signal in parallel with the ringer in the telephone. Restoring the key cuts off the external signal.

By changing two leads, arrangements may be made to disconnect the "parent" ringer when the external signal is switched on; however, this is usually not desirable.

Extension Exclusion

Turning the key excludes all extension telephones and places a "short" across the extension line to assure complete privacy.

Type 85B

This model features both the exclusion and switching key services. Two buttons, one chrome and one red, are located in the cradle. Normally the chrome button is in a raised position, and all extensions are connected to the line, as shown in Figure 3, the red button is depressed. Pressing the chrome button automatically excludes all extensions and shorts out the extension line; this action causes the red button to rise, indicating that the subscriber has line privacy. The extensions can be restored to the line by pressing the red button—or through a mechanical linkage shown in Figure 3, they are mechanically restored when the handset is replaced. The telephone is equipped with a six-conductor line cord.

Extension Exclusion

A typical extension exclusion arrangement is shown in Figure 4. Any of the three telephones may answer a call—or the "parent" Type 85B can exclude all extensions (and "short" the extension line) by merely depressing the exclusion button.

The Type 85B can be converted to various optional services, with a minimum of wiring changes.

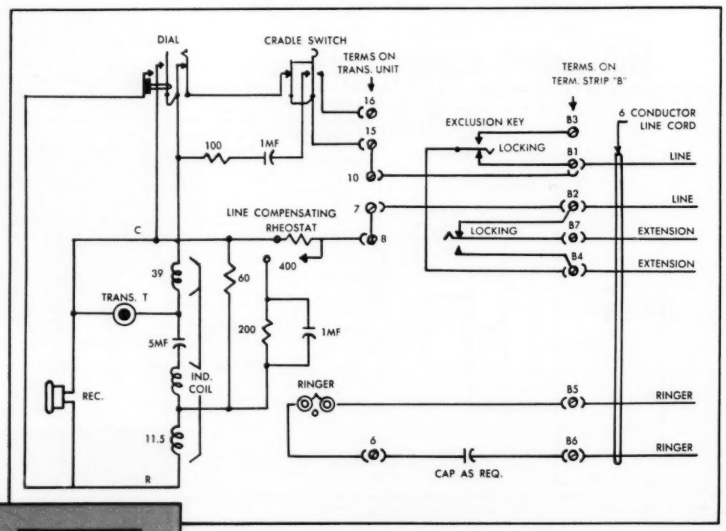

Figure 3. Schematic Wiring Diagram of Type 85B Telephone

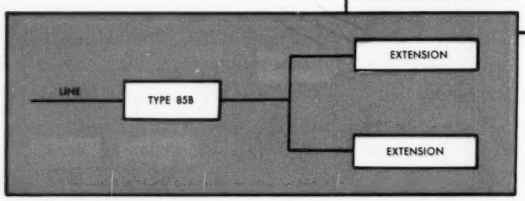

Figure 4. Typical Extension Exclusion Arrangement

Due to the restoring feature of the switching key, however, this telephone is not as flexible as the 85A.

Two Line Pick-up

When the handset is removed from the cradle, the telephone is connected to Line 1. Pressing the chrome button gains access to Line 2; replacing the handset restores the telephone to Line 1. Ringer arrangement is the same as with the Type 85A. No provision is made for holding a call.

Type 85C

This telephone combines the features of Types 85A and Type 85B telephones. The turn feature gives the subscriber access to either of two lines, and by using the push feature he may signal his secretary, by means of a light or buzzer, to come onto the line. The chrome and red buttons in the cradle are wired to provide exclusion of all extensions on one of the lines. The telephones can also be wired so that, by operating of the turn key, any one of three persons may answer or seize either Line 1 or Line 2, to answer a call without leaving his desk (see Figures 5 and 6). The telephone is equipped with a ten-conductor line cord.

To permit two-line optional wiring in the Type 85B telephone, a six-spring pile-up is supplied. In the Type 85C exclusion key a five-spring pile-up is supplied, since the turn key is wired for two line pick-up and alternate wiring not likely to be needed.

In either Type 85A or 85C telephones incorporating the push key feature, the push key can be wired for grounding instead of signaling; as used with Automatic Electric Type 33A6A and Type 95 P-A-B-X's, this provides non-restricted service. This feature would be in addition to any services the turn key feature is wired for.

Conclusion

Although many of the features of the Type 85 Telephone closely parallel those of the Type 87, the two instruments should not be confused. It is true that practically all of the services of the Type 85 could be provided by the Type 87, but in such cases the full utility of the Type 87 would not be realized—the telephone would be "over-equipped". Where the Type 85 can be used, it provides a most efficient and economical solution to service problems.

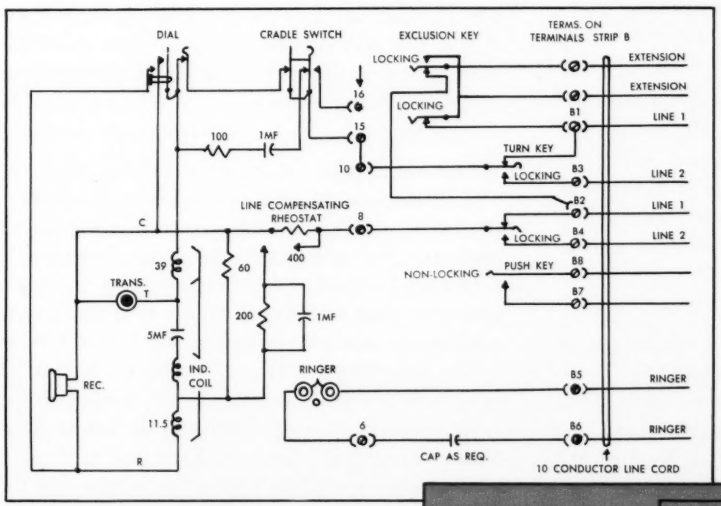

Figure 5. Schematic Wiring Diagram of Type 85C Telephone

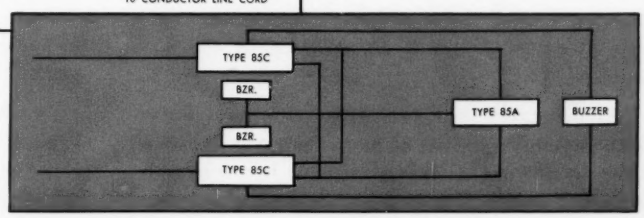

Figure 6. Typical Layout for Two-Line Answering with Extension and Secretarial Exclusion and Buzzer Signaling

THE TYPE 86 TELEPHONE

By G. A. Borling

The Type 86 Telephone is made in four- and six-key models, and is used with associated relay equipment and power supply in Type 10A1 Key Telephone Systems, providing pickup, hold, cut-off, and signaling facilities for up to six lines, and intercom service between up to nine telephones.

The Type 86 Telephone

—Can initiate and answer calls on a maximum of six C.O. or PBX lines

—Can initiate, answer, *and hold* calls on a maximum of five lines

—Provides full visual and audible supervision on incoming calls, held calls, and calls in progress

—Permits intercom service, pushbutton signaling, ringer or extension cut-off, and exclusion

—Is compatible with existing systems

The overall appearance of the Type 80 Telephone was retained in the Type 86 Key Telephone, but to incorporate the key-combination mechanism, the housing length and height were increased, and the dial angle was flattened to 29°, raising the front of the telephone.

To save space, a new transmission unit was designed, with new metallized paper capacitors, and a molded terminal block with tapped eyelet terminals and molded barriers. A pair of springs was added to the hookswitch to operate the "switch through", or line, relay in the Type 10A1 system.

Key Mechanism

The key mechanism connects the talking circuit to the central office, PBX, or intercom line. To do this it must connect the + and — terminals of the selected line to the talking circuit (through the hookswitch), and connect the hold lead of the selected line to the hold key; this requires three sets of make springs to be actuated by the line buttons.

As illustrated in Figure 1, a mechanical interlock prevents selection of more than one line at a time by placing a sliding segment between each adjacent pair of line buttons. Depressing any two

line buttons simultaneously causes the sliding segments to so align themselves that neither button can be depressed to the point where it will latch. The contours on the sides of these segments were chosen to permit only one push-button to reach the latching depth, but allow a second push-button to be depressed far enough to unlatch a previously latched button.

The ladder-type latching mechanism does not require mechanical adjustments, since the critical dimensions are built into the tool which blanks and perforates the side plates. The ladder assembly is permitted freedom of movement only in the direction of its long axis; the rungs are held against the push-button plungers by means of a helical tension spring (not shown). Thus a rung can "capture" a push-button when the plunger is depressed to the point where its shoulder is beneath the ladder rung. When the second plunger is depressed its tapered enlargement moves the ladder axially, allowing the latched plunger to escape; it is then restored to normal by the compression spring shown in Figure 1.

To place a call on "Hold", the hold relay in the Type 10A1 relay equipment must be energized. This circuit is completed through the springs of the hold key, in series with the closed springs of the

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depressed line key. This means that depressing the hold button must not restore the line button until after the hold relay operates. As shown in Figure 2, the rung of the ladder associated with the hold key floats free, retained by only two small springs. The contour of the hold plunger is such that when it is depressed the movable rung is displaced without moving the ladder; on restoring, however, the entire ladder is displaced, releasing the line button and clearing the instrument for a subsequent call.

Any line key may be employed as an intercom key, in association with the proper relay equipment. To provide a means for using spare keys as signaling keys, provision is made for converting certain keys to be non-latching. This is done by removing the guide screw (see Figure 3). The plunger then cannot latch on the ladder rung, and the key may be used as a momentary push-key for either code or selective signaling use.

To provide for ringer cut-off and extension cut-off, a two-position turn-key may be provided in the sixth position to operate a six-spring pileup. For extension exclusion, the Type 86 uses the same spring assembly as Type 85, with two spring combinations added to extend the H (hold) and B (balance) leads, as well as the R (ring) and T (tip) leads. In the "exclude" position the disconnected line is shorted to prevent stray pickup. In the "on hook" position the handset automatically reconnects the excluded line.

Visual Supervision

To provide the desired visual supervision, a 10-volt lamp is required to illuminate the push-button. The standard switchboard lamp was found to be too large, so the Lighting Division of Sylvania Electric Products, Inc., was called upon, and developed a miniature long-life lamp, rated at 200 foot-candles (measured at the end of the bulb). The push-button is contained by a guide which serves also as a shield to direct the light to the proper button. Both parts are molded in clear acrylic, and portions of the shield are painted white to confine the lamp output and prevent false illumination of adjacent push-buttons.

The designation strip, made of vellum paper, is also illuminated, by directing a portion of the lamp output through an opening in the telephone housing. To prevent mechanical bind between the case and the push-buttons, the push-button guides float in a retaining strip and are positioned by the cut-outs in the housing.

Audible Supervision

The single-coil ringer may be connected directly across one incoming line, receiving ringing current from the central office or PBX, or from a local ringing current source (through the relay equipment) when common audible signaling is used.

When used as a unit of the Types 10A or 10A1 Key Telephone Systems, the Type 86 Telephone provides a flexible multiple-line service without the need for operator supervision. Completely compatible with the major existing systems, it may be thought of as a small, unattended P-A-B-X.

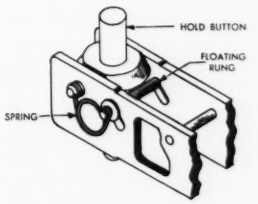

Figure 2. Floating Rung Retained by Spring

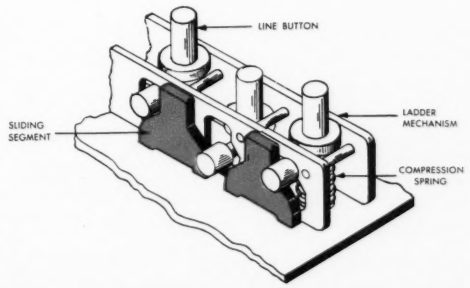

Figure 1. Mechanical Interlock Arrangement, Showing Sliding Segment and Compression Spring

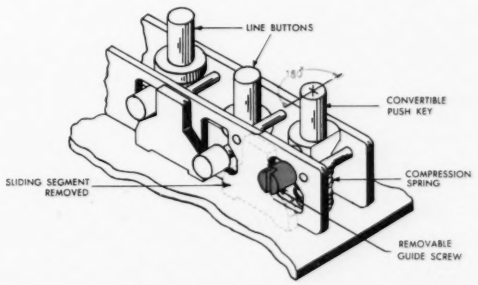

Figure 3. View showing Convertible Push Key Mechanism and Guide Screw

THE TYPE 87 TELEPHONE

By R. E. Spitler

The Type 87 Telephone provides line pickup and hold features for a maximum of three lines, without requiring external power, or relay controls. Visual indication of the line being called is provided, and a signal button is included for signaling a secretary and for operation of a P-A-B-X transfer circuit. Optional exclusion keys permit exclusion of all extensions from one line.

The Type 87 Telephone

—Gives fingertip access to three central office, P-B-X, or private lines.

—Provides signal button for external secretary's buzzer, and for operation of a P-A-B-X transfer circuit.

—Has two "hold" restoring systems—one to remove individual holds, and one for removing *all* holds placed on the line.

—Can have optional exclusion keys, allowing exclusion of all extensions from one line.

The Type 87 Key Telephone looks like the Type 86, except that a signal key has been added, below and to the left of the dial.

Transmission (Figure 1)

The circuit of the transmission unit is the same as the circuit used in the standard Type 80 Telephone, except that it has an additional 1 MF capacitor, which is used (in series with 100 ohms) for spark protection of the dial impulse springs. In the standard Type 80 Telephone, the capacitor in the ringer circuit is transferred by the hookswitch springs, and used to protect the dial impulse springs during dialing. This cannot be done in a multiple-line telephone such as the Type 87, that has only one transmission unit and one ringer. The ringer and its capacitor are associated with only one of the lines while the transmission circuit may be associated with any one of the three lines.

Hold Features

The Type 87 employs two distinct hold-restoring systems—one for removing individual holds, and one for removing all holds placed on the lines. Depressing a line button causes a toggle lever to push up the associated hold button. Depressing of the *right hand* hookswitch plunger will automatically restore all hold buttons. If the telephone is being used with a P-A-B-X system on an incoming call, the operator can be flashed by depressing the *left-hand* hookswitch plunger, without disturbing the holds on associated lines.

Line and Hold Buttons

The problem of obtaining the proper line and hold button action was solved by a system of toggle levers (see Figures 2 and 3). The row of six buttons below the dial is arranged in pairs of line and hold buttons, mounted on top of plastic plung-

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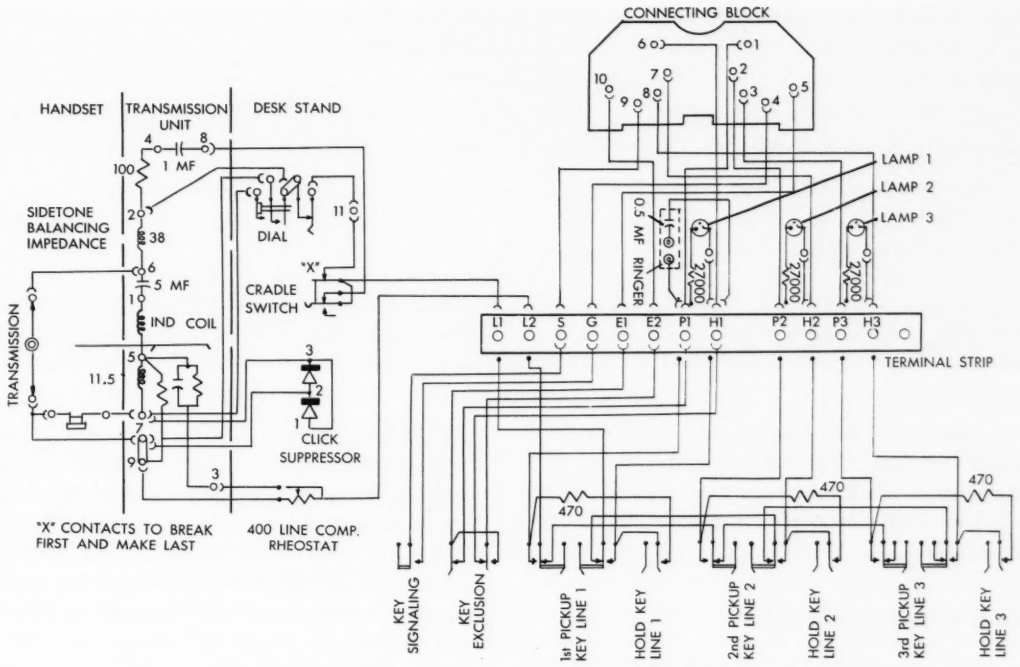

Figure 1. Wiring Diagram—Type 87 Telephone

ers. Each plunger has a cam and pin which operate the toggle lever system and a spring pileup, when the button is pushed down. As can be seen in Figure 2, depressing of any one line button will mechanically force its associated hold button up, and at the same time force any other line buttons which are down, to an "up" position.

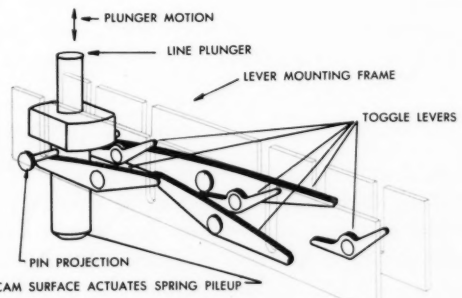

Figure 2. View Showing Action of Toggle Levers and Spring Cam Pile-up Action

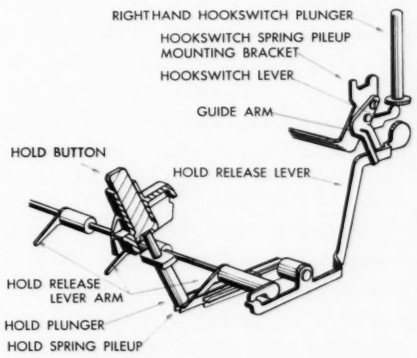

Figure 3. View Showing Action of Hookswitch Plunger and Hold Button

As shown in Figure 1, a 470-ohm holding bridge is placed across a line when its hold button is depressed; this resistance is low enough to hold the line connection, and high enough to permit conversation from other phones on a held line. When the handset is off its cradle all hold buttons may be depressed, allowing all three lines to be held at one time. A hold can, therefore, be removed by depressing its associated line button, or by replacing the handset in its cradle, which depresses the right hand hookswitch plunger which in turn re-

moves all holding bridges from the lines, by restoring all the hold buttons to their "up" positions as shown in Figure 3.

Incoming Call Indication

Visual indication on incoming calls is provided by the use of a neon lamp across each line, in series with 27,000-ohms resistance (Figure 1). Each lamp will flash when ringing current is impressed on that particular line. The flashing light is directed up through the plastic button by a shield; the light is also transmitted through the line designation strip.

To eliminate disturbing clicks in the receiver caused by inductive voltage surges from line switching, a "click suppressor" is mounted in the telephone and electrically placed across the receiver.

P-A-B-X Trunk Transfer

The signal button can be used to operate an external buzzer; it can also be used in certain P-A-B-X's to operate an incoming trunk transfer circuit. A typical P-A-B-X trunk-call transfer would operate as follows:

If a central-office call, originated or received at one local station, is to be transferred to another, the party at the original local station presses the signaling key, receives dial tone, dials the number of the station wanted, waits for that station to answer, and tells the called party of the call. As soon as the first party hangs up, the equipment automatically connects the called party to the trunk.

Exclusion Key

The optional exclusion key, when supplied, is wired to allow exclusion of all extensions from Line 1; or the installer can move the exclusion feature to either Line 2 or 3 by moving spade terminals at the terminal strip located under the dial. The dial is easily removed by loosening two screws on the dial mounting frame. The ten-conductor line cord is terminated on the terminal strip.

The exclusion key consists of a five-spring pileup mounted under the hookswitch, a pivoted Y-shaped actuating lever, a special hookswitch lever, and two push-button assemblies mounted above the dial, and in front of the handset. If the subscriber is talking on the line that the exclusion key is wired to, and he wishes to exclude all extensions from his conversation, he presses the chrome (left-hand) button. This operates the exclusion pileup and pushes up the red (right-hand) button. If the subscriber wishes to remove the exclusion while he is still talking, he presses the red button, which restores the exclusion pileup to normal. If the exclusion pileup remains operated at the end of the conversation, placing the handset in its cradle operates the special hookswitch lever, which in turn, moves the Y-shaped actuating lever to its normal position, thus removing the exclusion from the extensions.

The TRANSENDER and TRANSLATOR of the TYPE 59 SATT SYSTEM

By I. V. Coleman

In the Type 59 Strowger Automatic Toll Ticketing (SATT) System (see General Telephone Technical Journal, April, 1959) the principal trunk unit is the "Dual Service" Ticketer. It is seized at the start of a toll call—after the SATT access code has been dialed—and is held for the entire duration of the call.

One of its basic functions is to record and store the called and calling numbers; at the end of the completed call, these numbers are transferred to a Tabulator (see Figure 2) where all ticket data are permanently recorded by a Tape Perforator. All sending and most control functions are provided for the Ticketer by one of a group of Transenders. A Transender is held only during the setting up and sending of a toll call; its holding time is much shorter than that of a Ticketer, hence only about one-fourth as many Transenders as Ticketers need be provided. The Transender, in turn, refers to the common Translator to obtain routing and control information. Holding time of the Translator is very short; therefore only one need be provided for as many as 40 to 50 Transenders.

Type 59 Transender

The Transender, illustrated in Figure 1, normally consists of three basic "jacked-in" units—sender, coder, and codexer. An optional fourth unit, the MF control, is provided in installations requiring multi-frequency pulsing. The Transender receives the called code digits from the Ticketer, passes to the Translator the information necessary to obtain a routing and control directive, and then stores this directive, for use in outpulsing and controlling the operation of the Ticketer.

Each Ticketer has access to the Transender pool through its Transender hunter (a Type 45 rotary switch), which operates upon seizure of the Ticketer. In the standard Type 59 SATT System the hunt for an idle Transender can proceed while the first code digit is being dialed into the Ticketer, and during the succeeding interdigital interval; this affords a delay basis of access without the need for a second dial tone. The second and subsequent code digits are repeated to the Transender directly as they are dialed and stored in the Ticketer. The first code digit is sent to the Transender by a revertive pulsing method, while the second and subsequent digits are being received as dial pulses.

The standard Type 59 SATT System provides automatic number identification (ANI service) for one, two, and four-party lines, and operator identification (CKO service) for any type of line. System variations will provide automatic number identification (ANI) for ten-party lines—or ANI service on a semi-automatic basis. With both variations, dialing of the identification digit is required as a suffix to the access code and this provides time for connection to an idle Transender without the need for revertive pulsing.

In most cases the first three code digits (office code or area code) are sufficient information for the Translator to supply routing and control information. In other cases, however, calls to some offices in nearby numbering plan areas may be routed regularly via one or more direct trunk groups, while calls to other offices in the same foreign areas may require routing via the "principal city" route. In such cases, six-digit (foreign area) translation is required, since both the area

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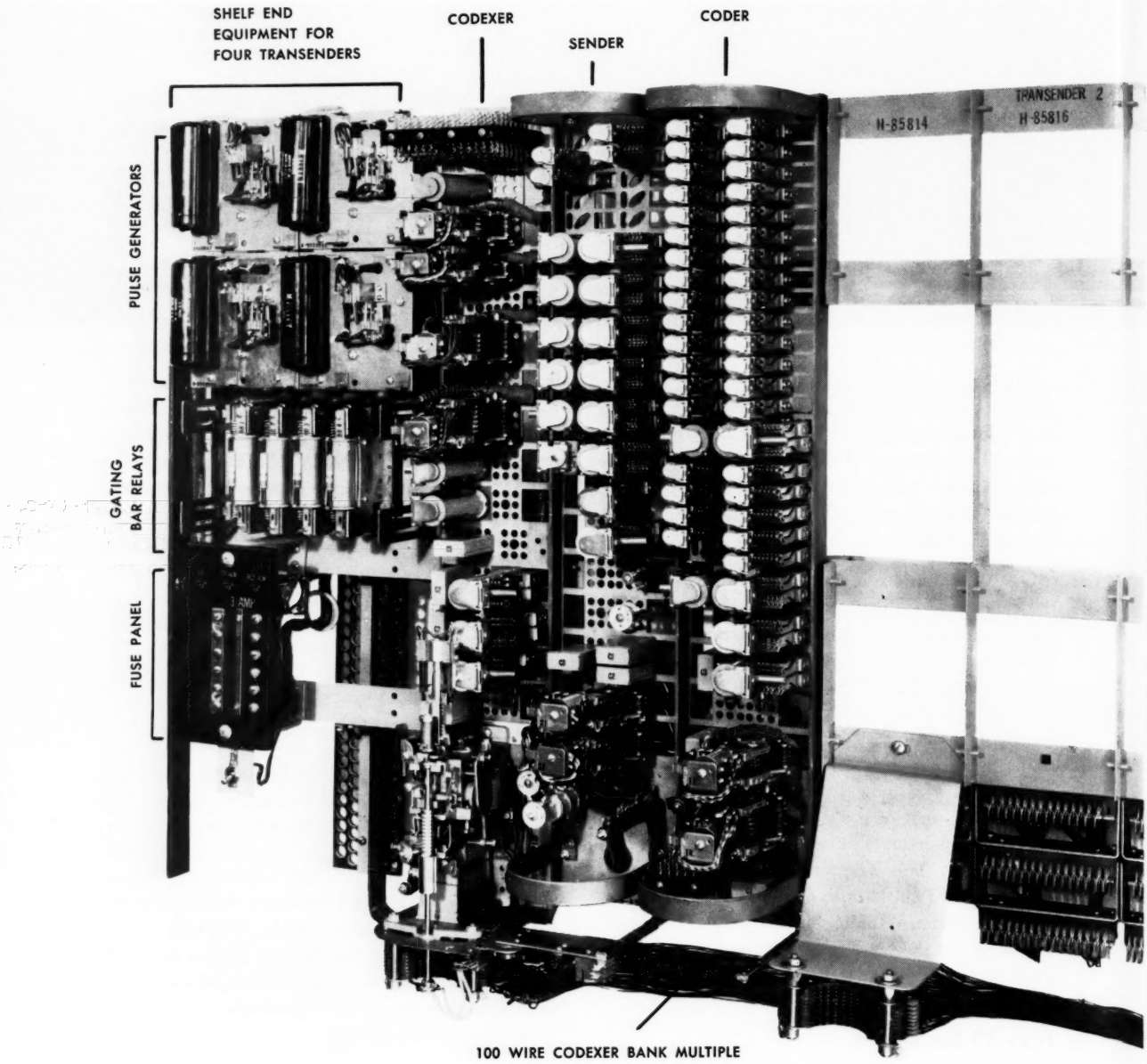

Figure 1. The Transender of the Type 59 SATT System

code and the office code must be analyzed before the proper routing can be determined.

Those area codes which require six-digit translation are marked by jumpers in a small terminal field in the codexer unit of the Transender; provision is made for a maximum of six such codes. Upon receipt of an area code which matches the jumpering, the Transender waits to receive the office code (next three digits) before calling for the Translator. Other area codes are translated on a three-digit basis in the "home" field of the Translator, in the same manner as home-area office codes.

Preparing for Translation

Before calling for translation the Transender must know also whether the calling number has been automatically identified or is to be obtained by a checking operator. When this information (plus the necessary called code digits) has been received from the Ticketer, the Translator assigner is alerted. The assigner functions to establish an exclusive connection momentarily between the calling Transender and the Translator.

Translation

The codexer unit of the assigned Transender marks the home-area lead, or one of the six foreign-area leads to the Translator, and presents the code for translation. In response the Translator presents the appropriate field of translator relays to the code-lead terminals. The selected relay then operates in accordance with the indicated code and presents its strapped-in routing and control directive for storage in the coder unit of the assigned Transender. This complete translation cycle occurs in a fraction of a second, after which the Translator becomes available to other Transenders.

Routing Digits

The directive provided by the Translator can supply up to six routing digits. These digits are used primarily for routing functions, such as trunk group selection and switching through tandem offices, but they may also be used for building up converted codes when needed. For example, if a call to an office in the home area is to be trunked via a switching center in a foreign area, the routing directive will include the digits of the home area code to be sent as a prefix to the originally dialed office code. In other cases, arbitrary "converted" code digits may be supplied in the routing directive, to be sent in place of part or all of the originally dialed code.

Control Markings

In addition to the routing digits, the directive from the Translator provides a number of "markings" which control the operation of the Transender. One of these is the deletion-control digit, which is received into temporary storage in the coder unit of the Transender, along with the routing digits. The deletion-control digit is sometimes called the "setter" digit, because it is used by the Transender to set the starting position of the outpulsing sequence switch in the Ticketer. This is the mechanism of deletion which permits the called number (area-code, office-code, and terminal-number) to be outpulsed in its entirety, or to be partially or completely skipped.

Other markings in the directive which may be used as required for the control of the Transender are:

(1) The TA mark, indicating that outpulsing is to start immediately upon completion of the translation cycle. This marking is applicable when the call is to be trunked to a direct-control office, either directly or via a step-by-step tandem.

(2) The TB mark, indicating that sending is to be delayed, pending a second translation after the conditions of delay (explained below) have been satisfied. The TB control mark is applicable when the call is to be trunked to or via a common-control office; its use insures against interruptions in sending which might otherwise cause time-out of an incoming register at a common-control office. If ANI service is employed, the TB control is also useful on calls to be trunked to direct-control offices having mixed numbering; its purpose here is to provide time for the dialing of a possible extra digit before the sender catches up.

When the TB mark is used, the Transender on first translation will accept only the TC and TE controls (see 3 and 5, below) then relinquish the Translator without accepting the routing and deletion control. On second translation the TB mark is equivalent to a TA mark; the Transender will accept all controls and the then prevailing routing (getting up-to-the-moment information) and begin sending immediately.

(3) The TC mark, indicating that 6-digit (2L-4N) numbers, either with or without area code, may be accepted (in the absence of a TC mark, 2L-4N numbers are considered incomplete). Extra-pull numbers are not ruled out by a TC mark; 2L-5N or even 2L-6N numbers will be accepted if the extra digit or digits are dialed without undue delay. Otherwise, however, the call will be accepted as a bonafide 2L-4N number. (This is a temporary condition to permit

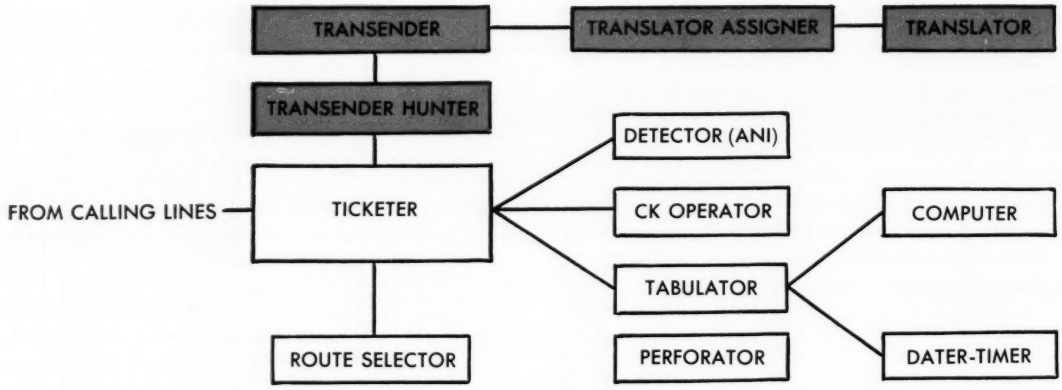

Figure 2. Block Diagram showing position of Transender and Translator in the SATT System

dialing into offices not yet conforming to conventional 2L5N numbers.)

(4) The TD mark, indicating that the CKO operator is to be by-passed, the entire called number is to be deleted (deletion digit "0" accompanies TD), and only the routing digits are to be sent. The TD control mark is applicable on the Translator used to block call attempts to non-dialable points. In this usage it is always accompanied by a TA control mark, so that it will be accepted on the first (and only) translation and therefore be effective in causing by-pass of the CKO operator.

The TD mark may also be used as part of an ultimate "alternate routing" translation, routing the call to a recorded announcement if the operating company prefers this rather than allowing the call to be directed, for a "pot luck" attempt, to an apparently all-busy final trunk group. Here a choice may be made either to route immediately with a TA mark (so that TD can cause by-passing of the CKO operator) or to use a TB mark to allow a second translation (after going to the operator) before determining that the call must be routed to the recorded announcement.

(5) The TE mark, indicating that the call for the CKO operator is to be delayed for approximately 5 seconds after the minimum expected number of digits (taking the TC mark into account) have been dialed. The TE mark is applicable to CKO calls into offices or areas with mixed numbering systems; its purpose is to allow time for dialing a possible extra digit before calling the CKO operator. Answer by the CKO operator does not, however, preclude the correct receipt of an extra digit. (Note: because of the delay it imposes on calls having the lesser number of digits, the TE control mark should not be used if the incidence of extra-pull calls is small.)

(6) The TF mark; this is a "spare" control mark, which is not used with the regular Type 59 SATT system. With the Type 59-FW SATT System, used in offices equipped with the FW-1 (four wire) toll switching system, the TF mark is used to indicate automatic ringing start.

Transender Response to the Control Directive

A TA control mark from the Translator causes the Transender to accept the routing digits and all controls. Marks sending begins immediately, permitting the call to be completed as quickly as possible. On ANI calls there will be no interruptions in the outpulsing, unless the sender catches up with the dialing of the rest of the called number; in this event each remaining digit will be outpulsed as soon as received. In the case of CKO calls the sending starts before the operator is called in, but the last two digits are withheld until she completes the keying of the calling number.

If a TB control mark is received upon the first translation, TC and TE controls can be accepted but the routing and any other controls being offered by the Translator will not be accepted at this time. In this case the Transender will call for a second translation following completion of dialing. On

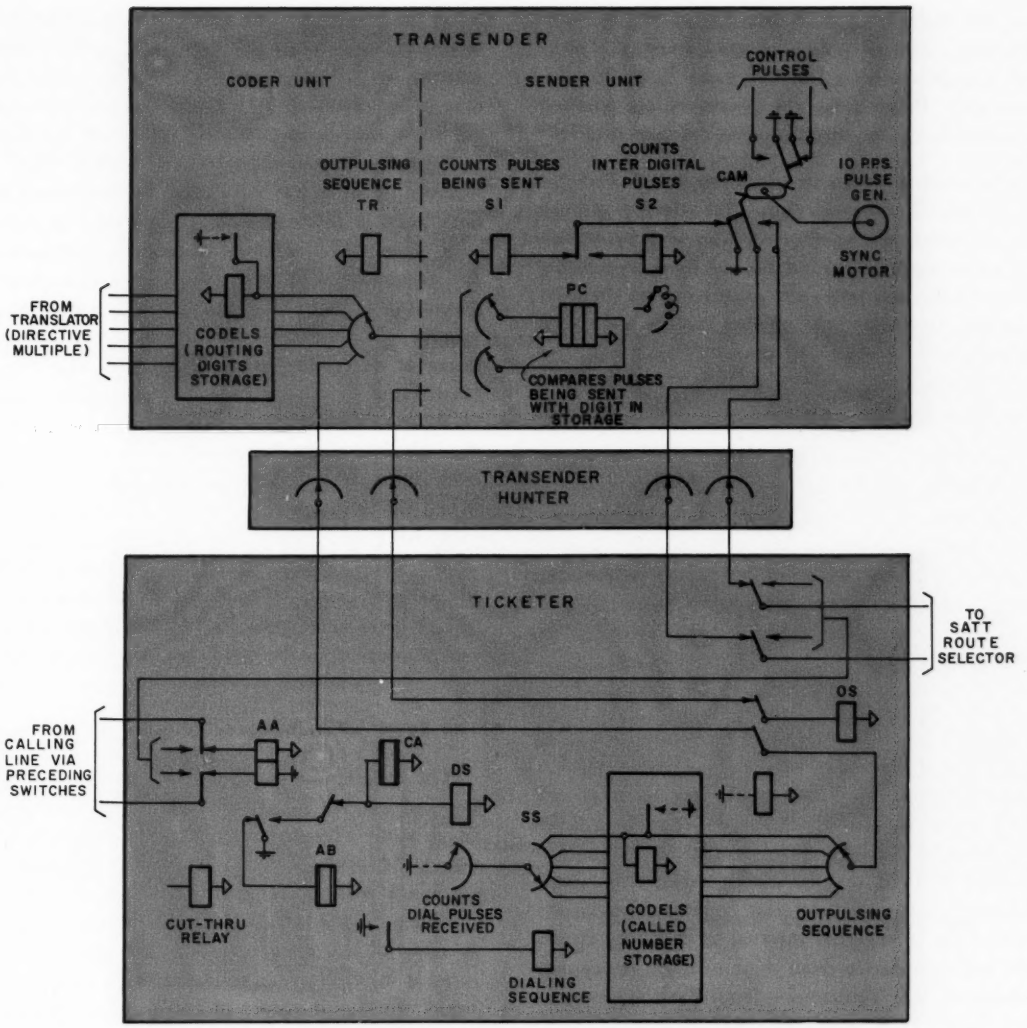

Figure 3. Schematic Diagram Showing Transender Sending Operation

CKO calls, keying of the calling number by the checking operator is also required before calling for the second translation. On such calls the Ticketer prepares to call in the operator when the called number has been dialed. Control of this function is exercised by the Transender and is interlocked with receipt of the first translation so that possible controls TC, TD, and TE may be applied.

Sending (Figure 3)

Immediately upon completion of the final translation—either one or two translations having been made as required—the sending operations of the Transender commence. A seizure loop is extended forward via the Ticketer to the SATT route-selector while the deletion-control digit is being pulsed to the Ticketer over a control path. The routing digits stored in the Transender coder are then outpulsed, followed by the required digits read from the called-number storage of the Ticketer.

Each Transender has its own dial-pulse source—a synchronous a-c motor-driven pulse-generator supplying loop pulses at 10 pulses per second and 41 percent make. This generator starts shortly be-

fore the outpulsing is to begin, and it runs continuously until all pulsing is completed. A "pick-up" circuit insures a full first pulse in each pulse train sent. Pulses from the generator are counted to establish the required interdigital intervals.

The pulsing loop extends through the Ticketer to the SATT route-selector. This selector is actually a transmission selector-repeater with provisions for pulse-repeating either SX or loop, depending upon the normal post cam adjustment on the level selected. The voice transmission path is not closed through until dial pulsing is completed.

Stop-Dial and Flash-Busy

Stop-dial and flash-busy signals are received by the Ticketer on the EC lead and repeated to the Transender. A stop-dial signal can be accepted by the Transender during either digital or interdigital intervals, but a digit being outpulsed will not be interrupted until a flash is recognized. An off-hook (or stop-dial) signal received prior to about 45 milliseconds from the end of the interdigital interval will prevent outpulsing of the next digit.

A flash-counter is provided to automatically release the Transender and the outgoing circuits upon recognition of flash-busy. Receipt of an off-hook signal causes the interdigital interval to be extended by 2.2 seconds so that flashing signals as slow as 30 IPM may be distinguished from single momentary stop signals; this counter resets at the end of the interdigital interval so that stop signals are not cumulative from digit to digit. Automatic release of the Transender from flash-busy causes the Ticketer to return 60 IPM busy-tone to the calling line. If flash-busy is encountered while the CKO operator is connected, the outgoing trunk will be released immediately but the Transender will not release and busy-tone will be withheld until the operator finishes.

Multi-frequency Pulsing

As previously noted, a fourth unit of the Transender, the MF control unit, must be provided if multi-frequency pulsing is to be used; in addition, a multi-frequency tone source is required. This will usually be common tone equipment serving all Transenders and the toll board as well.

In most cases, the MF-pulsed call will require the sending of one or more dial-pulsed digits to select the outgoing trunk group. These are received as routing digits from the Translator in the regular manner, each being one or two marks in the regular 4-element (WXYZ) Codel code. In the routing digit storage immediately following the digits to be dial-pulsed, a three-mark (WXY) "digit" is received. This is the KP "digit" which serves the dual purpose of causing the Transender to switch over to the MF mode and to send the preliminary KP combination of MF tones after extending a transmission cut-through mark to the SATT route selector. (Note that the KP digit is one of the maximum of six routing digits supplied by the Translator.) Any remaining digits in the routing storage of the coder are then outpulsed MF, followed by the required digits (normally seven or ten) read from the called number storage of the Ticketer. When the last digit stored in the Ticketer has been sent, the Transender will send the KP combination of MF tones (derived from Codel markings WXZ permanently wired in the coder), and then release. MF outpulsing is at the rate of five digits per second, controlled by the synchronous pulse-generator.

The Type 59 Translator (Figure 4)

The Translator provides a central store of routing and control information accessible to a group of up to 52 Transenders. It consists essentially of a group of multi-contact Bar-relays; some are equipped with small strapping fields to facilitate the jumpering in of a routing and control directive. A relay of this type is shown in Figure 5. (This relay is often referred to individually as a "translator" but for purposes of clarity it is referred to here as a "translator relay".) The deletion control digit and the six routing digits are marked in accordance with the Codel code by ground straps, four contacts being provided for each digit. The six individual control contacts, TA through TF, are also marked as required by ground straps. The 34-wire set of directive leads is multiplied to each translator relay and to a "gating" Bar-relay connected to the coder unit of each Transender. The routing and control directive is returned from an operated translator relay to the calling Transender over this path.

A Transender with a code ready for translation is momentarily (and exclusively) connected to the correct translator relay—that is, the one having the directive which is applicable to the office-code or

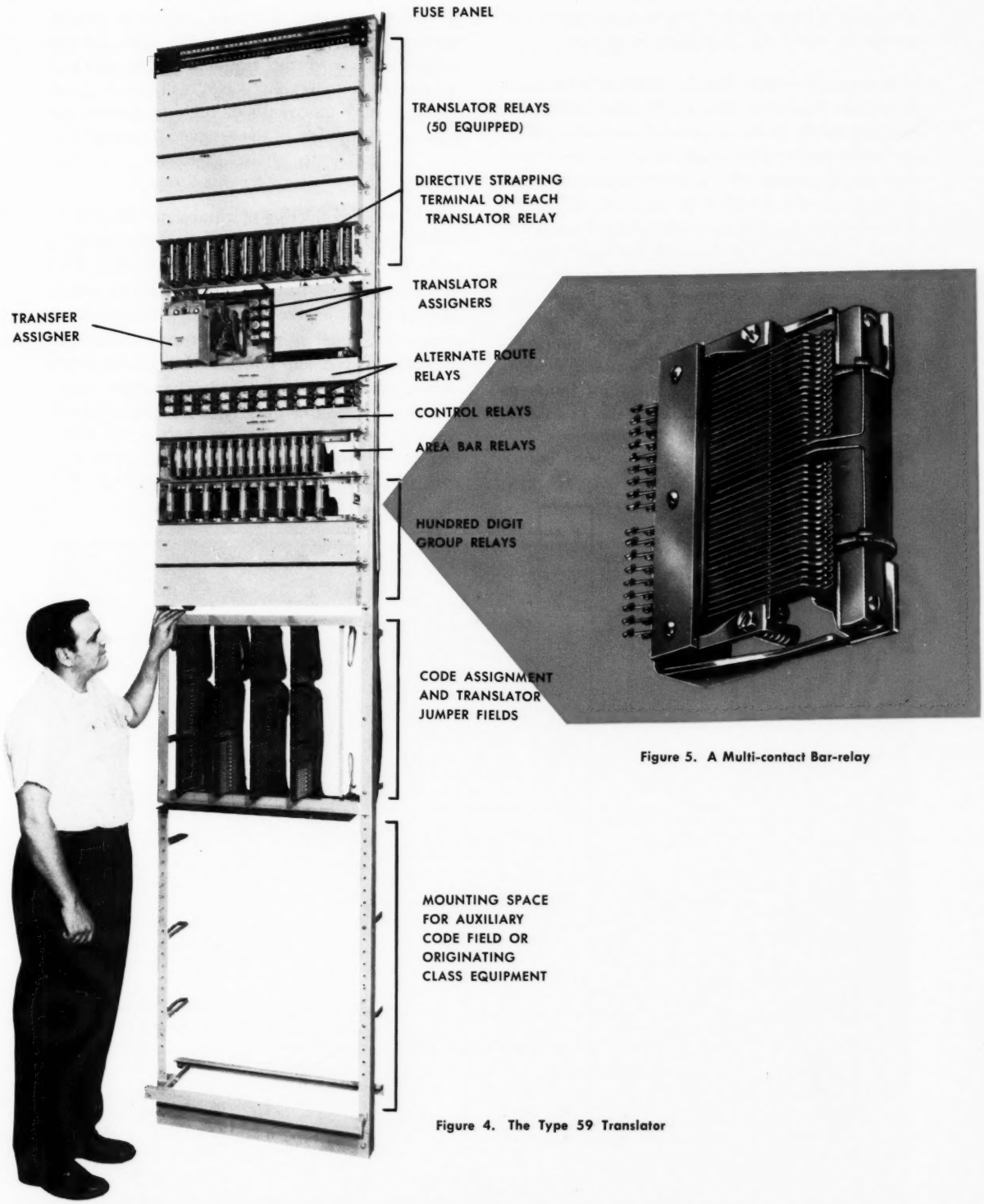
FUSE PANEL
TRANSLATOR RELAYS (50 EQUIPPED)
DIRECTIVE STRAPPING TERMINAL ON EACH TRANSLATOR RELAY
TRANSLATOR ASSIGNERS
TRANSFER ASSIGNER
ALTERNATE ROUTE RELAYS
CONTROL RELAYS
AREA BAR RELAYS
HUNDRED DIGIT GROUP RELAYS
CODE ASSIGNMENT AND TRANSLATOR JUMPER FIELDS
MOUNTING SPACE FOR AUXILIARY CODE FIELD OR ORIGINATING CLASS EQUIPMENT

Figure 5. A Multi-contact Bar-relay

Figure 4. The Type 59 Translator

area-code to be translated. Let us now consider the means by which the Translator is selected.

Assume office code F15 (= 345) is to be translated, (see Figure 6). The wiper of the two-motion codexer switch in the assigned Transender will be up to the 4th level (corresponding to letter I) and into the 5th rotary contact. A control ground closed to the wiper will therefore ground lead "45" of the 100-wire codexer bank multiple, which is also wired to the Translator. The first (or hundreds) digit of the called code is indicated by ground on the third lead (corresponding to letter F) of the 9-wire multiple, from a rotary switch in the codexer. This will cause the operation of the third set of hundreds-digit multi-contact relays in the Translator, extending the 100-wire multiple to the third hundred-group of the code lead terminals in the Translator, so that marked lead "45" now appears as ground-marked code-lead terminal "345". The battery-connected coil of the translator relay which is jumped to code terminal "345" will now be energized, causing the translator relay to operate and return the directive to the assigned Transender.

Six-Digit Translation (Figures 6 and 7)

The direct jumpering of a translator relay to the code terminal, as just described, would suffice if codes in only one area were to be translated. However, in most installations it is necessary to analyze office codes in one or more foreign areas in addition to the home area. In effect the translator relays are grouped into several fields by taking their operating jumpers through multi-contact "area" Bar-relays instead of directly to the code lead ter-

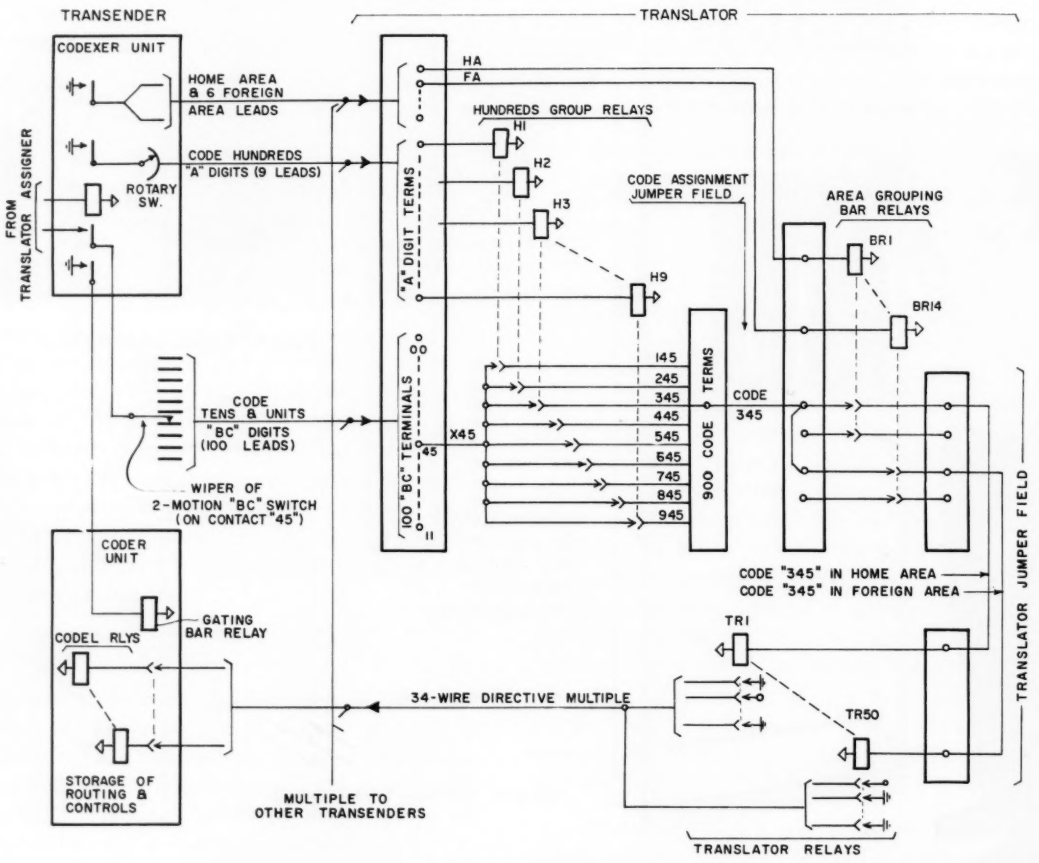

Figure 6. Schematic Diagram Showing Translation

minals. The assigned Transender, in addition to marking code "345" (in the previous example), will also ground the home-area lead, HA, or one of the six foreign-area leads, FA to FF. In response to this the desired area Bar-relays in the Translator will operate and present the appropriate translator field to the code-lead terminals. This permits code "345," for example, to operate one translator relay in the home area field or to operate a different translator relay in a given six-digit translated foreign area field.

Note, however, that the Translator in each case analyzes only a three-digit code. Six-digit translations are made with the help of the Transender to mark the appropriate area lead. For example, if code "345" were dialed following an area code which is not six-digit translated, the Transender would ignore the "345" code and present only the area code, at the same time marking home-area lead HA because all three-digit translated area codes are treated in the home translator field exactly as home-area office codes.

If an area code is dialed following another area code, the Type 59 Ticketer itself will block completion by immediately releasing the Transender and returning busy tone to the calling line. This being true whether or not the first area code is in the six-digit translated group, it is never necessary to provide jumpers for area codes in the foreign fields. It also follows that it is not necessary to take three-digit translated area code jumpers through the home area Bar-relays; either such codes may be jumped directly from the code terminals to the appropriate translator relays.

Translator Relay Jumpers (Figures 6 and 7)

Upon considering the translation system it becomes apparent that the number of translator relays equipped on the Translator rack need not be

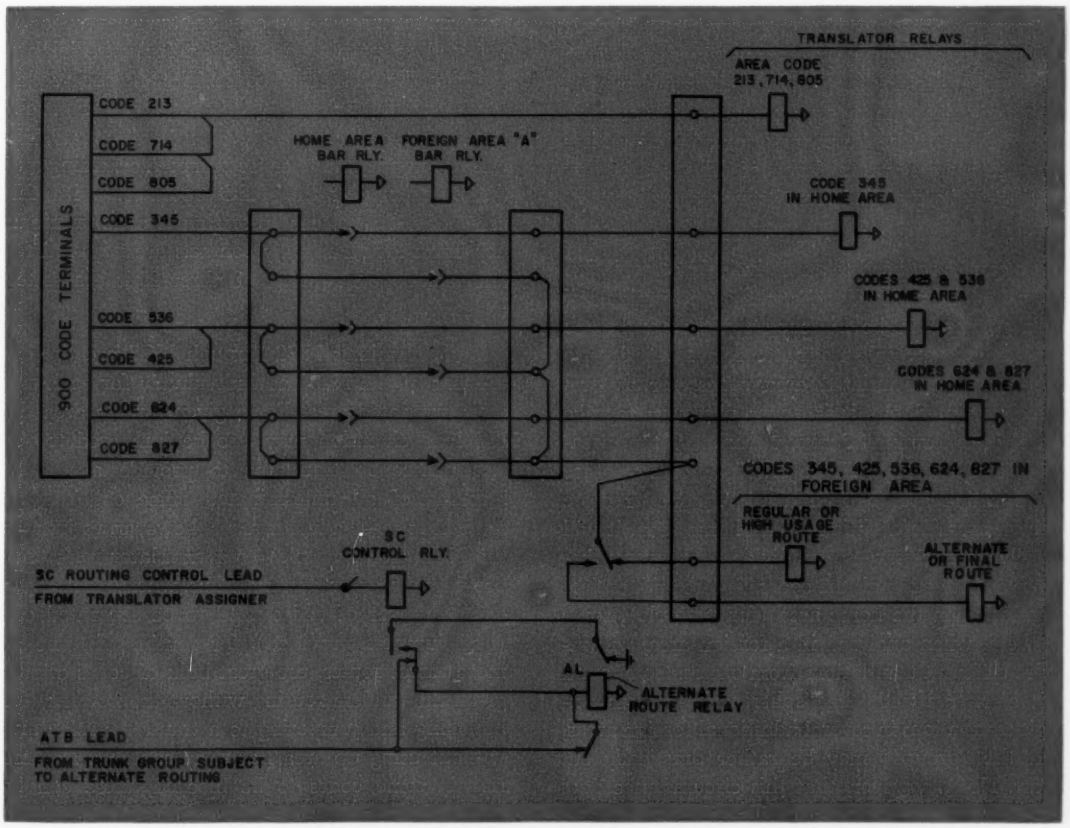
TRANSLATOR RELAYS
AREA CODE 213, 714, 805
900 CODE TERMINALS
CODE 213
CODE 714
CODE 805
CODE 345
CODE 536
CODE 425
CODE 624
CODE 827
HOME AREA BAR RLY.
FOREIGN AREA "A" BAR RLY.
CODE 345 IN HOME AREA
CODES 425 & 536 IN HOME AREA
CODES 624 & 827 IN HOME AREA
CODES 345, 425, 536, 624, 827 IN FOREIGN AREA
REGULAR OR HIGH USAGE ROUTE
ALTERNATE OR FINAL ROUTE
SC CONTROL RLY.
SC ROUTING CONTROL LEAD FROM TRANSLATOR ASSIGNER
AL
ALTERNATE ROUTE RELAY
ATB LEAD FROM TRUNK GROUP SUBJECT TO ALTERNATE ROUTING

Figure 7. Schematic Diagram Showing Translator Jumpering

very large (perhaps 30 or 40) even though a large number of codes can be dialed. For example, if a number of codes routed via a given trunk-group require the "C" digit plus a terminal number to be sent, one translator relay will suffice for this group of codes. Routing digits to reach the trunk group, the deletion-control digit to prevent the sending of the "A" and "B" digits, and the other controls as appropriate, will be strapped in on this translator relay.

Typically, a large number of codes will be routed to a switching center also equipped with translation and routing facilities. In this case a single translator relay, with the necessary strapped-in routing and controls to cause the entire dialed number to be sent, will serve a large number of codes. If this switching center is situated outside of the home area and both "via" and terminating codes are to be routed to the same trunk group, a second translator relay will be set up for the group of terminating codes, to provide for deletion of the dialed area code. Subdivisions into other translator relays may be made as needed to apply special controls TC and TE. In predominately step-by-step localities the translator relay requirements can be held to a minimum by sending code digits as originally dialed to be "used up" for routing, rather than deleting them in favor of wholly arbitrary routing digits supplied from translator relays.

The statement that "a great number of dialable codes can be reduced to a relatively few translation groups" perhaps implies that the code terminals of such groups can be bunched together and each jumpered to a single translator relay. This is true of three-digit translated area codes, for as previously pointed out it is never necessary to take these code-terminal jumpers through the area-grouping Bar-relays. However, in the case of office codes which are to be analyzed in one or more foreign areas in addition to the home area, it will usually be necessary to subdivide each group, because even though all the codes require an identical translation in the home area (for example), some of them, when analyzed in a foreign area, will require different translations from others. Compound this condition with the "splits" arising from six-digit translations in several additional foreign areas, and the "groups" may be rather drastically cut apart. Note, however, that this circumstance does not increase the number of Translators required (for the groups can be re-combined after being taken through the area Bar-relays); rather, it increases the number of contacts required on the area Bar-relays. The design of the Translator circuit copes with this problem in three ways: area Bar-relays are not placed in fixed groups, but are assignable in varying numbers to each area as required; an auxiliary code terminal field (to be described) can be provided optionally; special code lead "NC" provides for an automatic translation, individual to each area, for all code lead terminals not jumpered to a translator relay.

The NC Code Lead

The control ground supplied to the wiper of the assigned codexer switch is normally used to operate a translator relay. However, if the marked code lead is not terminated in a translator relay coil, the translator assigner will withdraw the control ground after a short interval and close ground directly to the Translator equipment via special code lead NC. Operation of the home-area control relay extends this lead to code terminal NC1. Usually the NC1 terminal is jumpered to a translator relay which is strapped to provide a directive for non-dialable, unassigned, and blocked codes. The "no-such-code" routing will be either to "intercept" or to "no-such-number" tone, as required. Controls TA and TD will be strapped in, to cause immediate sending and the by-passing of the CKO operator. With this usage of NC1, neither jumpering to code terminals nor home-area Bar-relay contacts are required for "no-such-code" routing of three-digit translated codes.

Code terminals NC2 through NC7 are the extensions of the NC lead individually for each six-digit translated area. For a given foreign area the NC lead extension may also be jumpered to the "no-such-code" translator to provide automatic blocking of all unterminated office codes. It is sometimes more advantageous, however, to jumper the NC2 (for example) to a translator relay that provides a regular routing. Thus, where a relatively small number of codes need to be separated out (and jumpers provided) for routing via one or more direct routes, the great bulk of codes can be given the tandem routing without the necessity for bunching and jumpering to a translator relay and without using up area Bar-relay contacts. If there remain some codes to be blocked, these can be jumpered (via area Bar-relay contacts) to the "no-such-code" translator relay. Operator and toll-

center codes preceded by an area code are already automatically blocked by the Type 59 Ticketer, and therefore cannot be given a routing of any kind by the Translator. (The criterion for blocking is "1" or "0" in the fourth or fifth code digit register, thus including area codes as previously stated.) This automatic blocking by the Ticketer makes the usage of NC for regular routing in six-digit translated areas especially advantageous.

Auxiliary Code Terminal Field

A feature of the Type 59 Translator is the provision (optionally) of the auxiliary code terminal field, which is in effect a second set of code leads completely independent of the regular set. A single jumper from each of the seven area control relays determines whether its codes will appear in the regular or the auxiliary code terminal field.

To illustrate its use, assume jumpering so that all codes of the home-area appear in the auxiliary field, while all office codes of six-digit translated areas appear in the regular terminal field. The advantage inherent in this arrangement is that translation groups of home-area office codes may be formed without regard to grouping requirements in other areas. Jumpers may then be taken directly to translator relays without employing any of the area Bar-relays for the codes in the home NPA. This not only reduces complexity at the outset but simplifies subsequent administration of the Translator jumpering when routing changes are made, new codes become dialable, etc. The auxiliary code-field equipment is not shown on the Translator rack as illustrated in Figure 4. On a rack of this type (11′-8″ high) the auxiliary field is mounted immediately below the jumpering field terminal blocks. It consists of an additional row of terminal blocks, below which are mounted three strips of Bar-relays serving the hundreds-digit function. These relays are exactly the same in function and appearance as those shown immediately *above* the jumpering blocks on the rack illustrated. (On nine-foot high equipment the auxiliary code field mounts on a separate frame.)

Alternate Routing Figure 7

Efficient trunking of subscriber dialed toll traffic requires provision of automatic alternate routing. This function is provided by the Type 59 Translator in a very straightforward way. Alternate-routing relays are provided in groups of 8 (plus two controls relays) and are mounted two groups to a plate. The coil of each alternate-route relay (AL) is connected to a trunk group A.T.B. lead so that the relay will be operated or released in accordance with the busy status of the trunk group. The esential element of each AL relay is a set of transfer (break-make) springs wired out to terminals in the translator jumper field. Jumpers from codes (or code group), requiring alternate routing are taken to translator relays via these transfering contacts, which pre-select either the regular or the alternate translator relay.

Each of the AL relays has a second set of translator-transferring contacts, which are used in cases where codes routed to the same trunk group are split into two translation groups to obtain code conversion, or differing deletion, or other controls. These additional contacts are useful also in connection with the route-control switches (optional) to be described later. A third set of break-makes is provided on each AL relay so that the make or break can be used as needed to light the associated alternate-route supervisory lamp on the SATT System Monitor Panel.

The trunk group ATB lead, connected to an AL relay coil, may be derived from either multiple breaks or a series of make contacts; it does not matter which type is used, so long as this is taken into account when the jumpers are run. The operating and locking paths to each AL relay are wired to the control relays, which operate, via routing control lead SC from the translator-assigner, each time a translation is in process. The associated circuitry prevents AL relays from either operating or releasing in the midst of a translation cycle.

A feature of the Type 59 SATT system is the close association in point of time between obtaining a routing directive and searching for a trunk in the indicated group. This enhances the effectiveness of high-usage trunking with alternate routing. The use of one-way outgoing trunk groups with SATT access only, and increasing availability of large groups by means of secondary rotary switches (either post-selecting or pre-selecting) will also help in this regard. A method which is extremely effective for small trunk groups is to provide direct overflow (via secondary switches) into the final route from late-choice outlets on the high-usage-group level. This trunking method can be used wherever sending requirements are compatible.

Route Control Switches

Route-control switches are provided optionally. In essence these are multi-position switches having one pole arranged for pre-determined switching of translator relays without the necessity for changing jumper wiring. Each route-control switch has a second pole that is used to light supervisory lamps.

In one usage, route-control switches may be operated to temporarily deny access to certain trunk groups (when certain codes are dialed, if desired), giving instead a translation to a "posted delay" or special instruction announcement. Another usage permits temporary cut-off of the alternate route, or substitution of one alternate route for another.

Blocking of EAS and Local Calls

Without additional apparatus, the Type 59 Ticketer will block calls to the caller's own office code. This provision is intended primarily to catch the accidental passing of the called number (rather than the calling number) to the CKO operator. The general facility which is provided optionally in the Type 59 Translator, is for control of translation by originating class and permits blocking of other local calls and of extended area service calls. Whenever calls between some points in a SATT network require routing through the centralized ticketing system, it is necessary to set up translations for those codes—and unless a means is provided for selectively blocking (or enabling) such translations, *all* local and EAS calls to these points are subject to completion via SATT.

This problem is usually not serious, and equipment to automatically block such calls generally cannot be economically justified. The requirement for such equipment does arise often enough, however, to warrant making translation control by originating class optionally available in the Type 59 Translator.

The technique of originating class identification is similar to that used in SATT System ANI Detectors, but the overall problem is much simpler. When assigned for translation, the Transender signals the Ticketer. If the Ticketer is held from a tributary access, it will respond by controlling the Translator and other apparatus corresponding to the class of the incoming trunk. The Translator in turn will provide a corresponding translation for use by the Ticketer. In the absence of an incoming trunk call response, a translation in accordance with a "local" class will be provided in the Ticketer.

Timing Controls

Timing of irregular holding and unstandard conditions is provided by a time-pulse counting switch in the coder unit of each Transender. When seized, this timer switch steps in response to the pulses from the SATT timing interrupter (which also generates the call timing pulses for the Ticketers, the Dater-Timer and other SATT equipments). In large installations the Transender timing pulses are also taken through a "time-pulse-changer" circuit which changes the pulses from the normal 6-second rate to the faster 4-second rate when the greater proportion of the Transenders become busy.

Timing Check Points

Timing check points are set up on the timing switch bank contacts as listed below. Intervals given are for the 6-second pulse rate.

T1 (24 to 30 seconds from seizure) Converts ANI call to CKO type if Detector normally converts an ANI call to CKO when it is unable to identify the calling number. The Ticketer will not call for detection unless the first two digits of the code (or the party digit) have been dialed before time-out. With some types of tributary ANI trunks the dialing time-out will block the call releasing both Ticketer and Transender.

T2 (30 to 36 sec. from seizure) Transender releases, Ticketer returns busy tone upon failure to complete dialing of code sufficient for translation.

T3 (42 to 48 sec. from seizure) Standby Translator assigner is placed into service in event the Transender is unable to obtain assignment for translation.

T4 (48 to 54 sec. from seizure) Transender releases, Ticketer returns busy tone if first translation is not completed.

T5 (54 to 60 sec. from seizure) Transender releases, Ticketer returns busy tone if the dialing of called number has not been completed. Timing switch is reset upon completion of dialing if within the allotted interval.

T6 (6 to 12 seconds from reset) Time-out in event of Translator-assigner failure causes standby Translator assigner to be placed in service. Functions on ANI calls with re-translation.

T7 (12 to 18 sec. from reset) Same action as T4 time-out upon failure of re-translation on ANI call.

T8 (42 to 48 sec. from reset) Final time-out of ANI call, causes Transender to release and Ticketer to return busy tone if all sending is not completed.

T9 (60 to 66 sec. from reset, excluding time CKO operator is on the connection.) Final time-out of CKO call, causes Transender to release and Ticketer to return busy tone if all sending is not completed.

Guard and Alarm Features

The Translator-assigner unit is provided in duplicate, with a manual transfer key and timed transfer to the standby assigner in the event of failure of the assigning action. Removal of either Translator-assigner unit from its shelf jacks will automatically place the duplicate unit in service. The Transender will resort to a "trouble translation", built into its coder unit, if it is unable to obtain assignment for regular translation.

A Transender normally relinquishes the Translator immediately upon receipt of the translation. Should the Transender fail to respond, the Translator assigner acts quickly, via an alternate path, to lock out the offending Transender and free the Translator.

The Translator equipment is actually a group of many separate relay circuits with sub-divided fusing and circuit arrangements so that failure in any of its elements will not affect translations. Therefore, this equipment is not provided in duplicate.

Occurrence of a sending failure (over-run, or sending of 11 pulses on any digit) will cause the Transender to disconnect itself from the Ticketer, and the Ticketer to return busy tone to the calling party. The Transender will lock to a reset key and give an alarm if sending over-run occurs while outpulsing from its routing digit storage. A blown fuse on any of the units of the Transender will mark the Transender busy and give a fuse alarm. Removal of any of its units from the shelf jacks will automatically guard the Transender against seizure.

The Ticketer and Transender circuits are designed so that the maximum available hunting time for a Transender is usable without danger that a Transender might receive a mutilated digit from being connected too late. The Ticketer permits hunting to continue as necessary until the receipt of the first pulse of a digit which is to be repeated to the Transender. The Codexer unit of the Transender is designed to accept pulses immediately upon seizure, there being no requirement for a "B relay soak" time.

The flexibility designed into the new Transender and Translator promises to greatly widen the application of the Type 59 SATT system in small- and medium-sized exchange networks.

NEW "Modular" POWER RACK

By M. R. Reid

It's not many years since the provisions for power and the allied ringing and tone-generating facilities in a telephone exchange occupied a very sizable amount of space. But the large, open jars of the old storage battery have been replaced by clean, closed jars of much smaller size; the bulky generator has developed into a compact and much more efficient static unit; and new designs in electronic ringing sources (more recently, using transistors) have greatly reduced the space required for these facilities.

As a part of this development, a new series of "modular" power racks have been developed which meet all requirements (including REA) for exchanges of up to 2000 lines or 100 amperes discharge rate. They are assembled on a standard frame, only 2′-0⅝″ wide and 9′-0″ high, which may be placed adjacent to the charging equipment. These racks replace the power shelves formerly used, and release critical space in the trunk boards, for functional switchgear. In view of the ever-increasing cost of exchange buildings, the resulting saving of space produces definite economies.

Careful analysis of exchanges within the size range chosen showed that their power requirements could be met by four basic "packages":

1. For single-frequency ringing, including five- and ten-code terminal-per-line and terminal-per-station ringing patterns
2. For superimposed ringing
3. For multi-frequency, one-ring, terminal-per-line and terminal-per-station ringing
4. For multi-frequency, one-and two-ring, terminal-per-line and terminal-per-station ringing

Each of these "packages" is built up of a number of standardized panels, some of which are used in all assemblies (see Figure 1). In most cases the panels are completely self-contained, with all external wiring ending at a terminal block.

Distribution Fuse Panel (A)

This panel was placed at the top of the rack to provide maximum access for the installation of the battery and ground connections and the distribution of fused leads to all trunk boards. Three separate assemblies will provide for 30-, 60-, and 100-ampere capacities; the 30-ampere assembly can be easily converted to a 60-ampere rating. Fuse distribution is provided in proportion to the discharge rating requirements: the 30-ampere panel provides for five 15-ampere fuses; the 60-ampere panel, for ten 15-ampere fuses; the 100-ampere panel, for ten 30-ampere fuses. Solderless connections, and a grounding bar are mounted on the back of the rack, next to the ground connections.

Transistorized Tone Panel (B)

A single transistorized unit with standby, or a triple-unit arrangement in cases where a distinctive ringback tone is desired, can be provided. The tone is pleasant to hear, and because this unit is transistorized it is almost maintenance-free.

Office Alarms (C)

This unit contains office alarm relays, and all necessary arrangements for handling the alarms.

Supervisory and Transfer Panels (D)

The panel that mounts in this position on the rack may be arranged to provide either continuous operation of both the primary and the standby ringing sources; or continuous operation of the primary source and start-stop operation of the standby; or start-stop operation of both sources. Paystation coin-control transfer relays, for any specific exchange requirement, available on interchangeable bases, can also be mounted optionally.

Ringing Relays (E and F)

Either five-code or ten-code relay units are available, with or without "standby". Circuitry is provided for two ringing groups, and two sets of interrupter leads, one each for terminal-per-station and terminal-per-line service.

Meter or Blank Panel (G)

This panel, approximately at eye level, provides space for any meters that may be desired in addition to the main voltmeter and ammeter mounted on panel (I).

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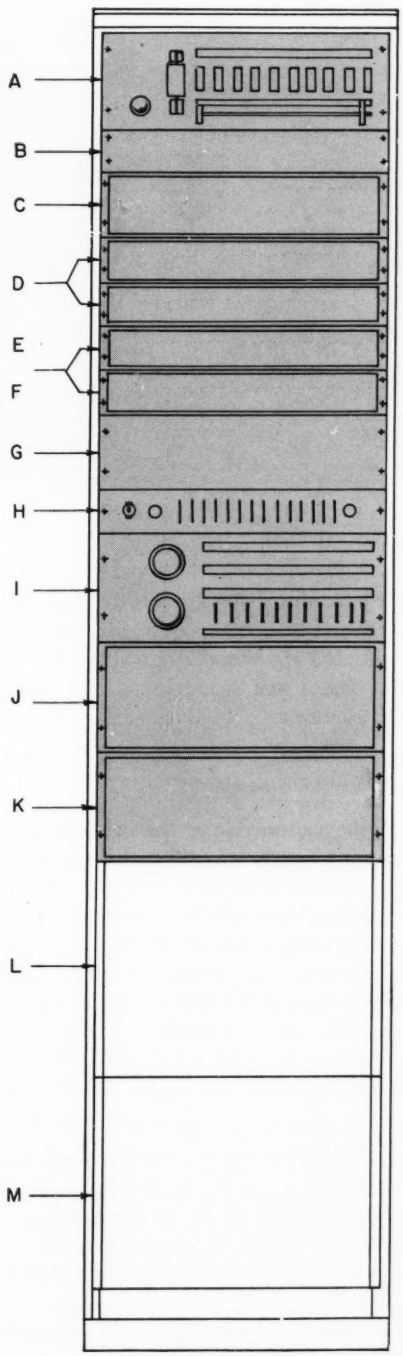

Figure 1. New "Modular" Power Rack Showing Individual Panel Units

D-C Fuse Panel (H)

The d-c fuse panel supplies all units on the rack, and the ringing supply. If coin control is required the battery is also fused on this panel.

Lamp, Key and Meter Panel (I)

This panel, placed at eye level, contains all lamps for registering the condition of the equipment, all keys needed to provide test access and manual transfer, and the main voltmeter and ammeter. Coin control lamps and keys are also arranged for, on an optional basis. The layout of a control panel providing all these features is shown in Figure 2.

Rotary Interrupters (J and K)

An a-c-operated unit provides ringing interruption and the IPM's and pulses needed by the specific exchange. A 48-volt d-c unit duplicates the services furnished by the a-c unit, on a standby basis.

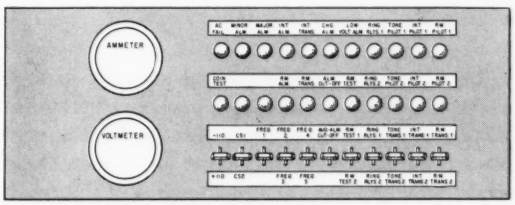

Figure 2. Enlarged View of Control Panel (I)

Ringing Current Supply (L and M)

The lower two panels are used for mounting commercial supplies of ringing current; they are ordered to meet the specific ringing requirements.

For multi-frequency ringing, arrangements have been made to furnish transistorized, electronic, or vibrator converters—or a combination, one for the primary and the other for the standby source (the transistorized and vibrator units are powered by 48-volt exchange battery; the electronic units operate from commercial a.c. and are therefore considered desirable as primary sources, by many operating companies).

For code and superimposed ringing, provision has been made for the following alternative supplies: two Subcycles (electronic) as primary and standby, using commercial a.c. supply; two transistorized units using d.c. supply; or one Subcycle as primary and one transistorized unit as standby. It was felt that there would be little need for vibrator units in this service, but such units can, of course, be made available.

This paper was presented by Mr. Osborn at the A.I.E.E. 1959 Fall General Meeting, Chicago, Illinois, October 11-16, 1959.

A FERRITE-CORE MEMORY SYSTEM and DISTRIBUTOR for a SMALL ELECTRONIC TELEPHONE SWITCHING SYSTEM

By P. E. Osborn

In recent years engineers and scientists in telephone research and development laboratories throughout the world have been turning an eye toward the future via the field of electronics. Some of the basic problems and philosophies of this trend in communications switching systems have been previously published[1] and some general approaches have been suggested. One such approach is that of the Time Division Multiplex technique in which intra-office transmission facilities are shared on a time basis.

The control of such a switching system presents some difficult and interesting problems, such as the proper sampling of the audio signal in the transmission network, the proper use of logic circuitry, and the storage and use of the information required to effect and maintain the inter-connection of two telephone subscribers. This article presents a unique and high-speed ferrite-core memory and associated circuitry which has been used in a small electronic telephone switching system[2]. The memory itself is an unusual application of a high-speed ferrite-core memory, but perhaps even more significant is the application of the "current steering" principle[3] for use as a pulse-distributor for this memory. The first part of this article will be devoted to the memory operation, and the remainder will describe, in detail, the design and operation of the ferrite-core pulse-distributor.

System Requirements

The primary function of the memory is to store information regarding a call between appearances of the time slot associated with the call, and to provide this information upon demand of the logic circuitry to initiate commands to the proper line gates in the transmission network. The information stored will be the telephone numbers associated with the call, and the supervisory information, such as the sending of ringing tone, busy tone, dial tone, ringback tone, and switching the call through.

The system is to provide forty (40) time slots of two (2) microseconds duration. Each time slot is divided into two parts; the first half-microsecond is used to read-out of the memory and to clamp the common highway to ground, and the last one and one-half microseconds is used to provide write-

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2. A Fully Electronic Automatic Telephone Exchange, D. K. Melvin, *General Telephone Technical Journal*, Vol. 6, No. 4, April, 1959.
3. Pulse Switching Circuits Using Magnetic Cores, M. Karnaugh. *Proceedings of the IRE*, Vol. 43, 1955, pp. 570-583.

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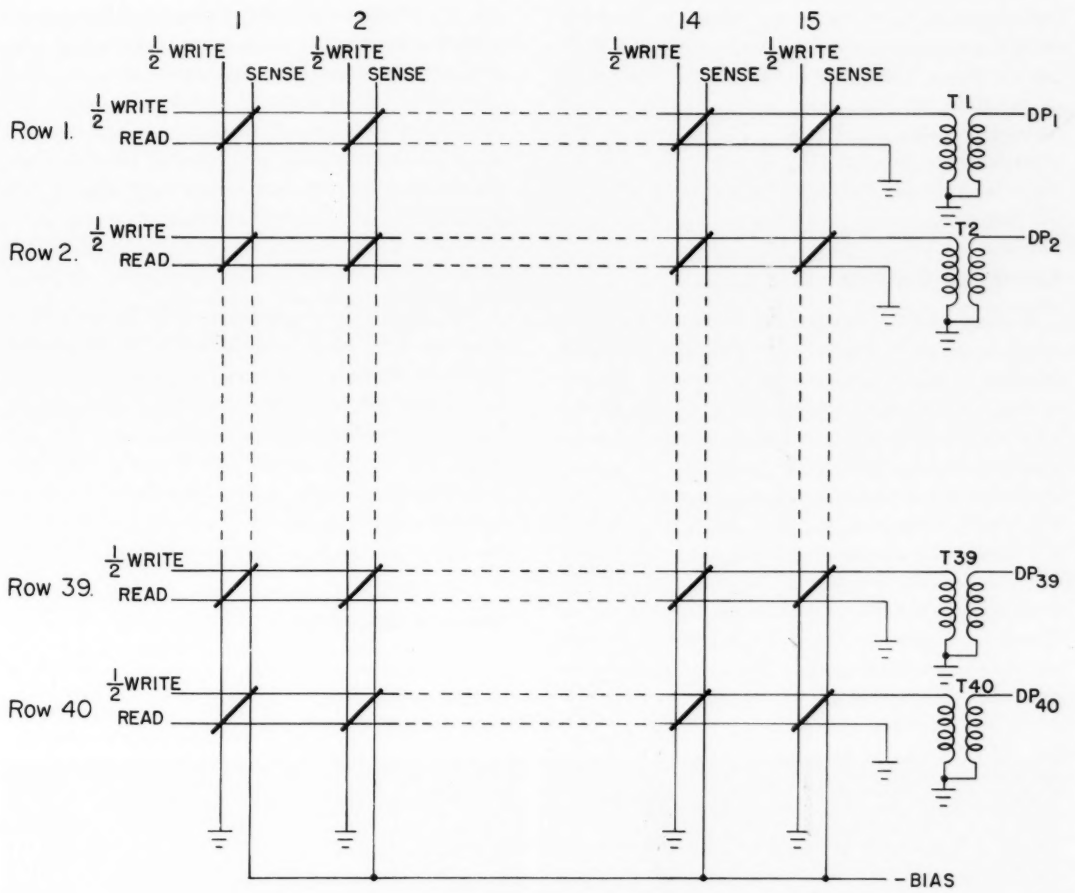

Figure 1. General Memory Arrangement

in time for the memory and also to provide the transmission time for the time slot. The pulse that occurs in the first half-microsecond will be referred to as the "read" pulse; the pulse occurring for one and one-half microseconds will be referred to as the "write" or "half-write" pulse.

Memory Description

The general memory arrangement is shown in Figure 1. Each horizontal row contains 15 cores which are arranged in three groups of five. The first five cores are for registration of the "tens" digit of the called or calling party's telephone number, and the second five are for registration of the "units" digit. The last five are for registration of supervisory or auxiliary information. The "tens" and "units" digits are registered in a two-out-of-five code. The memory is accessed horizontally from the left and vertically from the top. The read pulse is positive and the half-write pulses are negative. The horizontal access is a sequential access which is provided by the pulse distributor, and the vertical access is under control of the system logic. The first horizontal row is read-out in the first half-microsecond of the time slot, which is followed by a one and one-half microsecond half-write pulse. This read-write sequence is repeated in row two, then three, etc., through row forty, following which the sequence is repeated, starting again at row one. Thus the horizontal read-write sequence can appear in only one row at a time.

Each column has two windings—the "vertical half-write", and the "sense" winding. Since the horizontal read pulse is positive and the horizontal

and vertical half-writes are negative, the read-out on the sense winding will be positive. On the right side of Figure 1 the read pulse winding terminates in ground, but the write pulse winding passes through a pulse transformer. The output of this transformer is labeled DPn and provides the n^{th} time slot pulse for the circuitry associated with the n^{th} time slot.

Associated Circuitry

A block diagram displaying the associated circuitry is shown in Figure 2. The digit register and auxiliary register are transistor flip-flop circuits having a clock pulse, designated as CP-0.5, as the set *0* pulse and the memory output for a set *1* pulse (the terminology of "Set *0*" and "Set *1*" is conventional for ferrite core magnetic states). The register flip-flops can be set to the *1* state only if the core in the associated column has been written into the *1* state. The CP-0.5 pulse will appear coincident with a read-out pulse from the memory as shown in Figure 3. The CP-0.5 pulse is present whether there is an output from the memory or not, and the read-out must be able to over-ride this clock pulse. The CP-0.5 pulse is differentiated as shown in Figure 3, so that only the leading edge is used. The read-out then sets *1* after the lead spike of the differentiated pulse passes. The differentiated pulse passes through a diode to eliminate the positive spike at the end of CP-0.5. Thus, the register flip-flops are set to the *0* state at the beginning of each time slot, and are set to the *1* state only if the core in the associated column has been written into the *1* state.

The digit register outputs are sent to two places. They go to a diode matrix where the 2-out-of-5 codes are changed to 1-out-of-10 codes. There will be 1-out-of-10 codes for the "tens" and for the "units", providing 1-out-of-100 to control 100 line gates. The register outputs also go to the digit half-write windings, where system logic dictates either a half-write pulse in the same column that was read-out (re-write) or in a different column (advance).

Memory Operation

The memory operation may be seen by taking as an example row 5 (Figure 4). Assume the initial

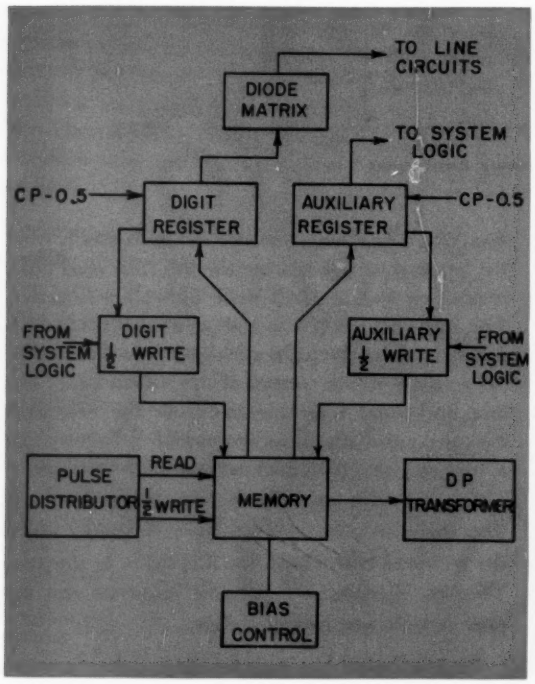

Figure 2. Block Diagram of Memory System

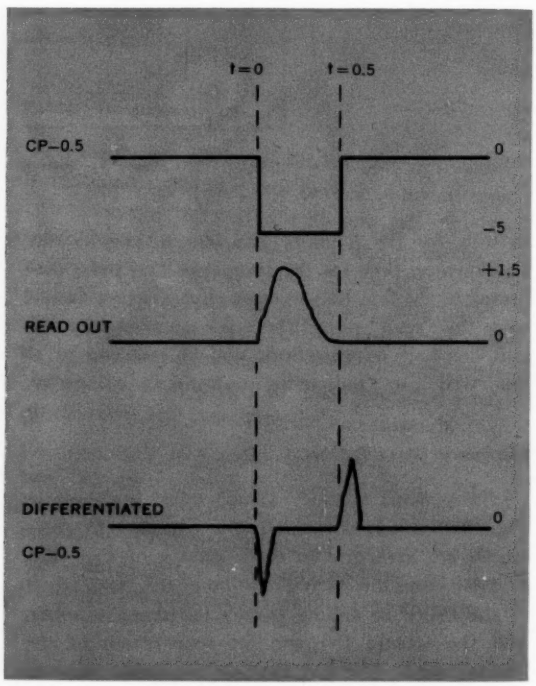

Figure 3. Pulse Time Relation

condition that cores C_T, D_T, C_U, and D_U are in the *1* state (this represents the number 11). When the read pulse appears the flip-flops associated with these columns will be set to the *1* state by read-out from these cores. If the logic condition is rewrite, then half-write pulses will be sent vertically through the columns Ct, Dr, Cu, and Du, thus re-writing the number 11 in time slot 5. If the logic condition is advance, then half-write pulses will appear vertically in Ct, Dr, Cu, and Du, thus writing the number 12 in time slot 5. The chart showing the code relation to numbers is shown in Figure 5.

The auxiliary register operates the same as the digit register and represents the various signals that must be sent to the telephone subscriber while a call is being set up.

The major design problem in this memory was the passing of vertical half-write pulses through 40 cores while setting only one of them. Since the sense winding is also common to these same 40 cores, the noise pickup from each non-set core is very large. There is also a noise pickup from the read pulse on cores that are not being switched. This problem was minimized by placing a diode in series with the sense winding, to eliminate all negative pulses (since only the positive read-out is desired) and leave only the positive noise spikes for further consideration.

Figure 6 shows the sense winding output for time slots 1 and 2 under various conditions. Figure 6 (a) shows the read-out of a *1* for time slots 1 and 2 without a vertical half-write in either time slot. Figure 6 (b) shows the readout of a *0* for time slots 1 and 2. Figure 6 (c) shows the read-out of a *0* for time slots 1 and 2 with a vertical half-write pulse in time slot 1. Here the noise pickup due to the vertical half-write is displayed, and it shows that the positive noise spike due to this half-write in time slot 1 appears to be the read-out of a *1* in time slot 2. Before anything could be done to compensate for this spike it had to be moved out of the succeeding time slot. This was accomplished by reducing the vertical half-write pulse to 1 microsecond. Figure 6 (d) shows the read-out of *0* from time slots 1 and 2 with the 1 microsecond vertical half-write pulse in time slot 1.

Reducing the vertical half-write to 1 microsecond meant that the memory core used had to be one that would operate properly on 1 microsecond half-write pulses—that is, twice the maximum repetitive half-write ampere turns has to be greater than the minimum full-write ampere turns. The core that meets these requirements is the RCA type 222M2 ferrite core. Once this core was selected it was decided to leave the horizontal half-write at 1.5 microsecond and assure better coincidence between vertical and horizontal half-write pulses. Reducing the vertical half-write pulse to 1 microsecond did not solve all the problems, for though the noise was no longer coincident with the read pulse of the next time slot, compensation for it was still required. The effect of this noise was eliminated by a bias-control circuit for termination of the sense winding. The bias control is provided by terminating the sense windings on the collector of a transistor. The transistor is turned on during the read-out and is turned off during the write pulse.

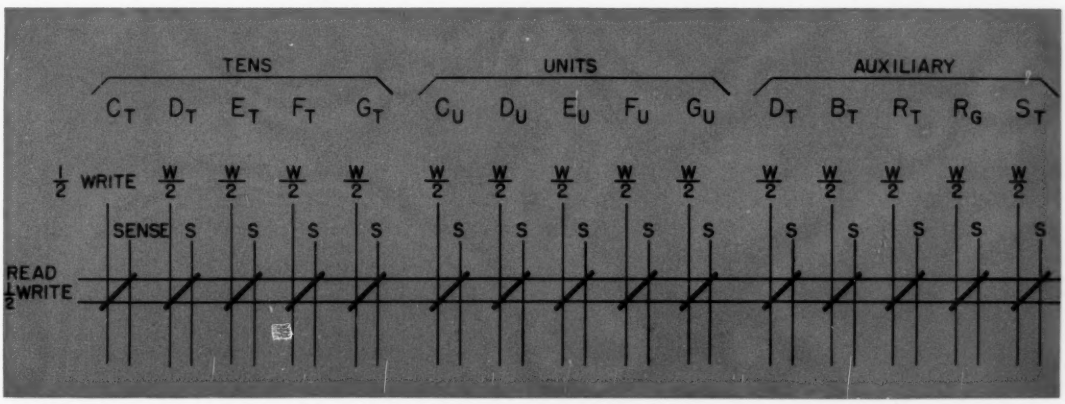

Figure 4. Memory Row 5

	C	D	E	F	G
1	X	X			
2		X	X		
3			X	X	
4				X	X
5	X				X
6	X		X		
7		X		X	
8			X		X
9	X			X	
0		X			X

Figure 5. Two-out-of-Five Numbering Code

With the transistor turned off, the sense winding terminates in the negative collector voltage. With the transistor turned on, the sense winding terminates in ground. Figure 6 (e) shows the output waveform on the sense winding for a *1* read-out and vertical half-write for time slot 2. The slight negative bias during read-out is produced by placing a silicon diode in series with the sense winding and collector of the bias control transistor. This slight negative bias will prevent the read-out noise, as displayed in Figure 6 (b), from operating the register.

The Ferrite Core Distributor

The horizontal access circuitry has the advantage that it is a sequential operation. This eliminates necessity for external control and simplifies circuit operation. The most straightforward way to produce pulse-distribution would be to use counter circuits with an amplifier for each read and write winding. The number of flip-flops required for counting 40 would be 6, since $2^5 = 32$ and $2^6 = 64$. To amplify each pulse would require 80 transistor amplifiers. Using a configuration whereby two amplifiers at a time would be turned on, for each pulse, would require a minimum of 26 amplifiers. (In the latter case the best number combination is 5 and 8, that is, 5 amplifiers each paralleled to 8 rows and 8 amplifiers each paralleled to 5 rows, making a total of 13 amplifiers. Since there are two pulses for each row the total would be 26 amplifiers.)

To reduce the number of amplifiers necessary to drive the memory, a magnetic pulse-distributor was used. This distributor uses ferrite switch-cores and applies a current-steering principle. Using this current-steering principle it was possible to reduce the total number of amplifier circuits to 4, and the total number of flip-flops to 1.

Operation of the pulse-distributor requires two input pulses, and since each memory row requires two pulses—a read and a half-write—the distributor fits the requirements of the memory.

A ferrite switch-core is similar to a memory core in that it has a high remanence, but it differs in that a switch core need not meet any half pulse undisturbed requirements; that is, a switch core will always receive full read and write pulses.

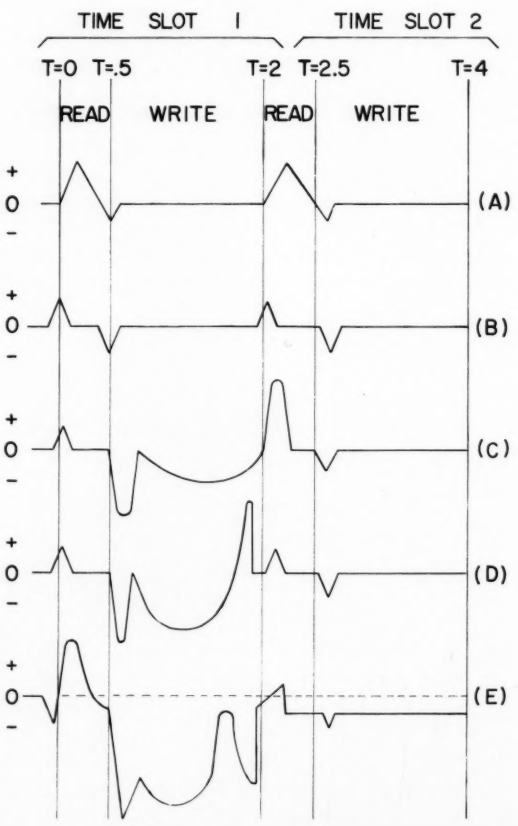

Figure 6. Sense Winding Voltage Waveshapes

Principle of Operation

The principle of operation of the distributor can be explained by referring to Figure 7. Assuming the core is in state *1*, a current in the direction of I_1 will switch the core to state *0*. If I_1 switches the core it will induce a current I_2 in N_2, and if the voltage induced in N_2 is large enough to overcome the voltage drop in the load and in the diode CR-1, due to I_2, then the transformer relation $N_1I_2 = N_2I_1$ can be met. Now if N_1 is greater than N_2, then I_2 would tend to be greater than I_1. A study of the circuit will show that I_2 cannot be greater than I_1 since any current in this direction must pass through N_1. With the above conditions met, all input current I_1 will pass to the load and no current will be shunted to ground through CR-2. Design of this circuit follows from a voltage standpoint. Knowing the load voltage and diode voltage and knowing the secondary voltage per turn developed by the core, the number of turns, N_2, can be determined. N_1 is determined by the relation that $N_1I_1 - N_2I_2$ will be the ampere turns that switch the core. The equation for finding N_1 is $N = N_2 + \frac{\text{Amp. turns to switch}}{\text{Iin}}$ and the voltage requirements are shown in Figure 8.

The circuit of Figure 7 would be only "one shot"—that is, stored information would be destroyed upon read-out and the core would have to be reset. The circuit of Figure 9 would be a continuously operating circuit. In this circuit the read core is set to the state *1*. When the read pulse enters, it will be steered through N_2, through N_3 of the write switch core, and off to the load. Read current through N_3 of the write core sets it to the *1* state, and therefore, when the write pulse comes in it will be steered through N_3 of the read core and on to the load. The write current will be such that it appears as a half-write at the load. This circuit would continue to function as long as the read-write sequence continued.

Figure 10 shows the ultimate pulse-distributor as used in this electronic switching system. In this circuit one core is state *1*, all other cores are state *0*. As each read core is switched it will set the write core directly below. As that write core is switched it will set the next read core above. This continues until the last write core is switched, which in turn sets the first read core. By this arrangement, once the distributor starts it will continue to function,

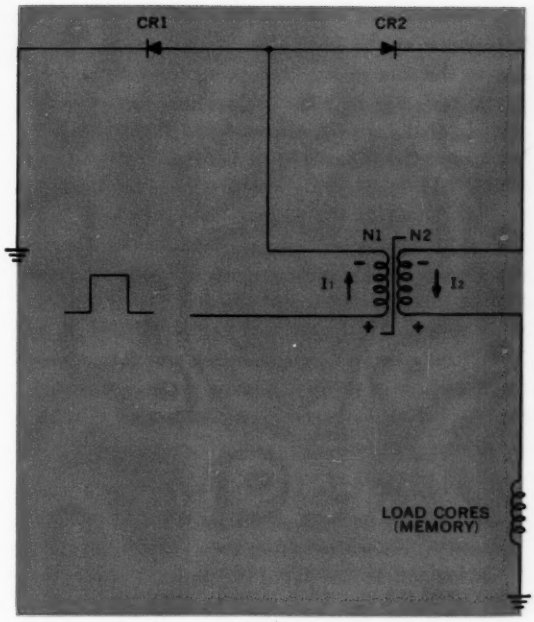

Figure 7. Circuit Arrangement using Current-Steering Principle ("One-shot")

recycling once for every 20 read-write pulses. This distributor then will supply 20 pairs of read-write pulses to 20 rows of the memory, one row at a time, thus giving 20 separate time divisions.

In the system two such distributors are used. The clock read-write pulses are fed through a scale of two, counter to the driver amplifiers. Thus one distributor feeds the odd-numbered memory rows, and the other feeds the even-numbered rows.

Original design considerations assume no losses in the switching core, and also that there is no impedance offered by the cores that are not being set. As the current I_1 passes through the primary

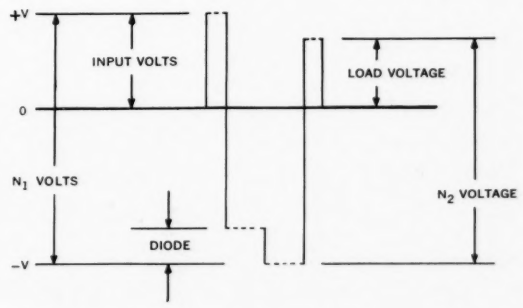

Figure 8. Voltage Requirements for Current Steering

(N_1) winding of each *0* state core it will see an impedance at the beginning of the pulse. This is due to the flux in the core going from Φr to Φm. There will also be some capacitance between N_1 and N_2 of the core. Since each non-switching core has L and C (Figure 11), it becomes a time-delay circuit and, considering the first core in the row, I_1 will appear in the primary and start switching the core before it becomes available to the secondary. During the delay time there will be no current flow in the secondary, and since the total ampere turns switching the core will be "$N_1I_1 - N_2I_2 = N_1I_1$," the core will start to switch very fast. A very small amount of delay will cause the core to switch entirely before I_2 becomes available and thus the distributor will fail.

In design the L and C must be kept at a minimum. C can be kept down by winding N_1 and N_2 on opposite sides of the core. The inductance is determined by the turns N_1 and the squareness ratio Φr/Φm. Since N_1 is fixed by the load, a switch core must be chosen with a high Φr/Φm ratio. With a particular switch core, and N_1 and N_2 wound with minimum capacitance, there will be a definite limit to the number of distributor stages for a particular load.

By the use of the magnetic distributor the access circuitry was simplified and reduced in size. Each 20 stage distributor is mounted on a printed circuit card. One card is mounted on each side of the memory, thus making the entire memory and distribution unit one small package.

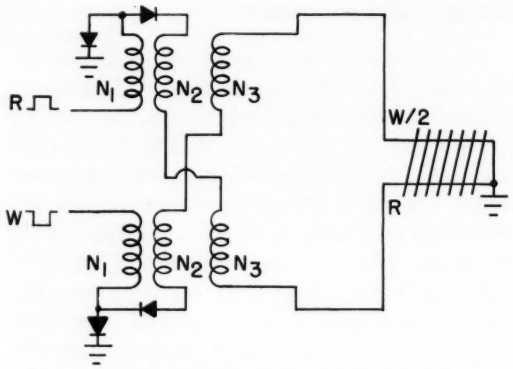

Figure 9. Continuously Operating Circuit using Current Steering

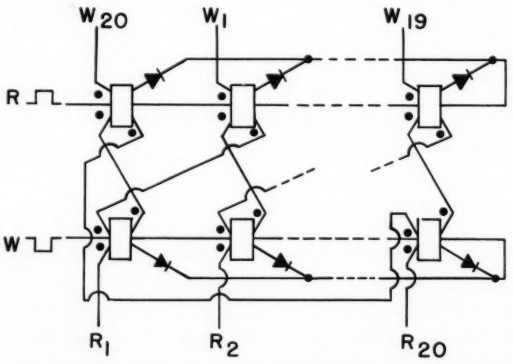

Figure 10. The Complete Pulse Distributor

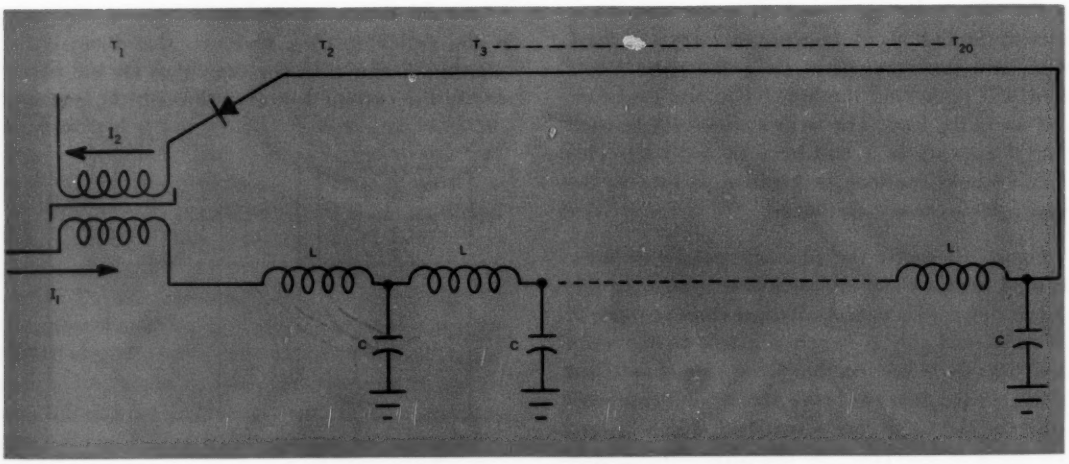

Figure 11. Time Delay in Non-Switching Distributor Cores

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